

METHODS OF DIAGNOSIS

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"Gentlemen, the cause of science imposes on you a difficult task. You must not assume that you have the explanation for any phenomenon of Nature until every alternate hypothesis has been exhausted."—Claude Bernard.

WITH 143 ILLUSTRATIONS

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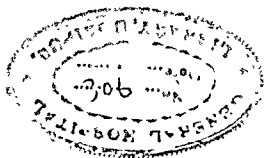
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To
OUR FRIEND
D. H. C.

PREFACE

The physician at the bedside of the patient—that is the picture I have had in mind in the preparation of this treatise.

The physician at the bedside of the patient, in making a diagnosis, first gets the patient's own story, and on the basis of his experience and the accumulated knowledge of others, analyzes these symptoms as to their meaning. This is the subject of the chapter on symptoms.

Then he proceeds to examine the patient carefully for signs of disease. This he must do himself. He cannot delegate it to anyone else. He must therefore know the technique of physical diagnosis. I have gone into this technique considerably more thoroughly than the accounts found in the elementary texts on physical diagnosis. Again, after accumulating this data he interprets it. This—technique, nature of the signs, and interpretation of the physical examination—is the subject of the chapters on physical diagnosis.

Then the diagnostician is brought reports from the various laboratories. While he may have performed, at some time or other during his student or professional career, the technical procedures involved, under the stress and rush of practice he cannot and is not expected to perform them himself in the case of every patient. But he must interpret the reports of the laboratory technicians.

The patient does not say to the physician, "I have amyotrophic lateral sclerosis," or "I have typhus fever," but "I am dizzy," or "I have lost weight," or "I have a pain." The average textbook in medicine takes up the description of diseases under their proper names, and is not therefore of help to the physician at the bedside of his patient until after he has determined what disease is present. This work therefore discusses the diagnostic possibilities of a given case, starting from the symptoms or from the signs, or from the laboratory data or x-ray picture, or the electrocardiographic record which the patient presents.

Our thanks are especially due Dr. Edward H. Skinner for his careful review of the chapter on x-ray diagnosis.

LOGAN CLENDENING.

The above was written by Dr. Clendening shortly before his death. I should like to add something that he would not include in his remarks; namely, that the contents of this book are based on more than twenty-five years of bedside teaching of physical diagnosis. Coupled with his superb use of speech was always a colorful presentation of the topic, an entertaining illustrative story, or the acting out of physical features, anomalies, gaits, or speech to drive home his point and seal it in the student's memory.

A great teacher, a loyal friend of the student, and a fine gentleman was Logan Clendening, my warm friend and co-worker for these twenty-five years.

EDWARD H. HASHINGER.

Kansas City, Mo.

CONTENTS

PART 1

PRINCIPIA DIAGNOSTICA

CHAPTER 1

	PAGE
LOGIC AND DIAGNOSIS - - - - -	1
<i>Definition, 1; Nature of the Mental Processes Used in Diagnosis, 1; Need for Conscious Application of Laws of Logic to Diagnosis, 2; Outline of Logic Applied to Diagnosis, 4; Résumé of the Forms and Principles of Logic, 7; The Sophists, 7; Deduction, 17; Propositions and Syllogisms, 17; Analogy, 22; Induction, 23; Probanda and the Nature of Proof, 36; Summary of Logic and Diagnosis, 48.</i>	

CHAPTER 2

THE ORGANON OF DIAGNOSIS - - - - -	52
<i>Accumulation of Data, 52; Judgment of Data, 52; Judgment of Trustworthiness and Reliability of Data, 52; Physical Examination, 53; Differential Diagnosis, 59; Judgment of Primary or Secondary Value of Data, 61; Judgment of Cause and Effect, 62.</i>	

PART 2

THE PATIENT

CHAPTER 3

THE HISTORY - - - - -	77
<i>Interpretation of Symptoms, 77; Pain, 78; Pain in the Head: Headache, 83; Thoracic Pain, 90; Causes and Relative Frequency, 90; Pain in the Arm, Shoulder, and Neck, 92; Abdominal Pain, 92; Differential Diagnosis of Abdominal Pain, 99; Backache, 104; Pain in the Legs, 110; Anesthesia, Paresthesia, 111; Fatigue, 113; Anorexia, Hunger, Thirst, Nausea and Vomiting, 115; Weight Change, 117; Pallor and Cachexia, 117; Symptoms Referable to the Digestive System, 118; Symptoms Referable to Disease of the Urinary Tract, 127; Symptoms Referable to the Circulatory-Respiratory System, 129; Symptoms Referable to Diseases of the Respiratory System, 141; Symptoms Which Point to Disturbance of the Nervous System, 145.</i>	

CHAPTER 4

THE PHYSICAL EXAMINATION - - - - -	157
<i>The General Methods of Physical Diagnosis, 158.</i>	

PART 3

ANATOMIC REGIONS

CHAPTER 5

THE BODY AS A WHOLE - - - - -	174
<i>Temperature, Pulse, Respiration, Chills, Sweats, 174; Weight and Height, 176; Posture, 177; Stature, 177; Contour, 178; Constitution. General Bodily Build, 183; The Skin, 189; The Endocrine System, 207; Stature, 209; Changes in Fat Metabolism—Fatness and Leanness, 219; Sexual Manifestations of Endocrine</i>	

Disease, 223; Anomalies of Intelligence, 231; Eye Changes in Endocrine Disorders, 231; Skin in Endocrine Disorders, 232; Muscular System in Endocrine Disorders, 234; Disturbances of Sugar, Salt, and Water Metabolism in Endocrine Disease, 237.

CHAPTER 6

EXAMINATION OF THE HEAD - - - - - 233

General Shape of the Skull, 238; Face, 238; Examination of the Mouth, 241; Lips, 241; The Gums, 244; Teeth, 245; Tongue, 250; The Tonsils, 251; The Salivary Glands, 253; The Eye, 255; Examination of the Eye, 257; The Ear, 265; The Nose, 266; Physical Examination of the Neck, 267; Classification of Swellings in the Neck, 267; Muscles of the Neck, 276.

CHAPTER 7

CHEST, ABDOMEN AND BACK—EXTERNAL FEATURES - - - - - 277

General Contour, 277; Ribs and Sternum, 279; The Axilla, 281; The Breast, 282; Examination of the Umbilicus, 286; Hernia, 287; Groin—Lymph Node Enlargement, 289; Phlebectasis, 291; The Spine, 292.

CHAPTER 8

DISEASES OF THE CARDIOVASCULAR SYSTEM - - - - - 298

Inspection, 301; Palpation, 304; Palpation of the Pulse, 304; Palpation of the Heart, 314; Percussion, 318; Auscultation of the Heart, 318; Clinical Features of Endocardial Murmurs, 332; Mitral Valve Disease, 334; Mitral Stenosis—Mitral Regurgitation, 334; Aortic Valve Disease, 341; Congenital Heart Disease, 344; Blood Pressure, 347; Arteriosclerosis, Hypertension, 353; Examination for Cardiac Failure, 361; Anginal Heart Failure, 366; Diseases of the Myocardium, 376; Diseases of the Pericardium, 382; Diseases of the Aorta, 387.

CHAPTER 9

EXAMINATION OF THE CHEST—THE RESPIRATORY SYSTEM - - - - - 396

Diseases of the Respiratory System, 396; Peculiarities, Anatomic and Pathologic, as They Affect the Physical Examination of the Respiratory System, 396; Routine Physical Examination of the Respiratory System, 396; Schema for Interpretation of Localized Physical Signs in Diseases of the Respiratory System, 402; Incidence of Respiratory Disease, 404; Diseases of the Respiratory System, 405; General, 405; Diseases of the Bronchi, 406; Diseases of the Lungs, 412; The Pneumonias, 419; Diseases of the Mediastinum, 430; Diseases of the Diaphragm, 432; Diseases of the Pleura, 435.

CHAPTER 10

EXAMINATION OF THE ABDOMEN - - - - - 445

Peculiarities of the Abdomen, Anatomic and Pathologic, As They Affect Physical Diagnosis, 445; Routine Plan for Examination of the Abdomen, 445; Methods of Examination of the Abdomen, 447; Relative Frequency of Abdominal Diseases, 452; Presenting Sign—General Distention of the Abdomen, 453; Presenting Signs—Rigidity and Tenderness of the Abdomen, 456; Presenting Sign—Abdominal Hemorrhage, 460; Presenting Sign—Localized Tumor, or Rigidity, or Tenderness, 461; Upper Left Quadrant of the Abdomen, 461; Upper Right Quadrant of the Abdomen, 466; Tumors of the Upper Right Quadrant, 468; Other Tumors of the Right Quadrant, 473; Diseases of the Lower Right Quadrant of the Abdomen, 474; Inflammatory Lesions of the Right Lower Quadrant, 474;

Tumors of Right Lower Quadrant, 477; Diseases of the Left Lower Quadrant of the Abdomen, 478; Inflammatory Diseases of the Lower Left Quadrant, 478; Tumors in the Left Lower Quadrant, 480.

CHAPTER 11

THE EXTREMITIES	481
-----------------	-----

Routine of Examination and Interpretation of Symptoms and Signs in Peripheral Vascular Disease, 511; Diseases of the Veins, 512; Diseases of the Peripheral Arteries: Routine Study for a Patient With Peripheral Vascular Disease, 514.

CHAPTER 12

FEMALE GENITALIA	524
------------------	-----

CHAPTER 13

MALE GENITALIA	527
----------------	-----

CHAPTER 14

THE RECTUM	532
------------	-----

CHAPTER 15

THE NERVOUS SYSTEM	534
--------------------	-----

Diagnosis of Diseases of the Nervous System, 534; Introductory, 534; Outline of Examination of the Nervous System, 534; Minimum Examination for Mental Status (5 Minutes), 548; Diseases of the Nervous System, 549; Diseases of the Motor System, 549; Paralysis of Peripheral Nerves, 549; Syndromes of Central Lesions Causing Cranial and Peripheral Nerve Disturbances in the Head, Neck, and Shoulder Region, 556; Flaccid Paralysis—Generalized, 560; Hyperactivity of the Muscles. The Dyskinesias, 582; Diseases of the Sensory System, 595; Neuralgias, 595; Anesthesia—Pain, Temperature, Proprioceptive and Vibratory Senses, 602; Coordinated Functions, 606; Speech, 606; Equilibrium, 607; Mental States Due to Organic Disease, 610; Disorientation, Confusion, Character Change, Dementia, 610; Stupor, Somnolence, 613; Coma, 615; Delirium, 615.

PART 4

LABORATORY AND SPECIAL PROCEDURES

CHAPTER 16

EXAMINATION OF THE URINE	616
--------------------------	-----

CHAPTER 17

EXAMINATION OF THE BLOOD	623
Normal Standard Values, 623; Interpretation of Abnormal Cells in the Blood Smear, 624.	

CHAPTER 18

BLOOD CHEMISTRY	629
Normal Standard Values, 629	

CHAPTER 19

THE SPUTUM	640
------------	-----

CHAPTER 20

	PAGE
EXAMINATION OF THE GASTRIC CONTENTS	642

CHAPTER 21

EXAMINATION OF THE STOOL	645
------------------------------------	-----

CHAPTER 22

FUNCTIONAL TESTS	647
Functional Liver Tests, 647; Functional Kidney Tests, 650.	

CHAPTER 23

THE CEREBROSPINAL FLUID	654
-----------------------------------	-----

CHAPTER 24

TRANSUDATES AND EXUDATES	659
------------------------------------	-----

CHAPTER 25

IMMUNOLOGIC TESTS—BLOOD AND SKIN	662
Serologic Tests for Syphilis, 663; Negative Serologic Tests for Syphilis, 665;	
Agglutination Tests, 666; Skin Tests, 667; Bacteriologic Methods, 671.	

CHAPTER 26

X-RAY DIAGNOSIS	672
---------------------------	-----

X-ray Examination of the Bones and Joints, 672; Diseases of Bones, 673; Other Infections in Bones, 680; Endocrine and Metabolic Changes in Bone, 684; Miscellaneous Bone Diseases, 686; Congenital Anomalies and Anatomic Variations of Bone, 688; Diseases of the Joints, 689; X-ray Aspects of Lumbago, 691; X-ray Diagnosis of Pain Around the Joints, 693; X-ray Diagnosis of Diseases of Muscles, Bursae, and Veins, 695; X-ray Examination of the Heart and Great Vessels, 695; Shadows of the Cardiac-Aorta Area, 695; Heart Shadows or Silhouettes, 695; The Aorta, 697; Exact Heart Measurements, 700; Diseases of the Respiratory System, 701; X-ray Examination of Nasal Accessory Sinuses, 701; Fungus Infections of the Lungs, 712; Diseases of the Pleura, 716; Free Fluids, 716; Fixed Fluids, 716; Diseases of the Mediastinum, 725; The Diaphragm, 727; X-ray Diagnosis of Diseases of the Digestive System, 730; Teeth, 730; Appearance of the Normal Structure of the Teeth on the X-ray Plate, 731; Diseases of the Teeth, 732; The Esophagus, 736; The Stomach, 745; Methods of Examining the Stomach by X-rays, 747; What to Observe and Record in Stomach Roentgenograms, 748; Roentgenologic Diagnosis of Diseases of the Stomach, 749; Carcinoma of the Stomach, 757; The Intestines, 761; The Appendix, 765; The Colon, 765; Diseases of the Colon, 766; The Gall Bladder and Ducts, 774; X-ray Diagnosis of Diseases of the Kidneys, Ureters, and Bladder, 778; X-ray Examination of the Central Nervous System, 783; Encephalography, Ventriculography, Myelography, 783.

CHAPTER 27

THE ELECTROCARDIOGRAM	784
---------------------------------	-----

Interpretation of Electrocardiogram, 784; Value of the Electrocardiogram, 786; Disturbance of Rhythm, 788; Extrasystoles—Premature Systoles—Premature Ectopic Beats—Ectopic Beats—Premature Contractions, 788; Tachycardias, 791; Bradycardia, 795; Effect of Drugs on the Electrocardiogram, 802.

	CHAPTER 28	PAGE
BASAL METABOLISM - - - - -		813
<i>Limits of Normal, 815.</i>		
	CHAPTER 29	
OPHTHALMOSCOPY, OTOSCOPY, AND LARYNGOSCOPY - - - - -		818
The Retina, 818; Pathologic Retina, 819; Syphilis of the Retina, 819; Embolism of Central Retinal Artery, 822; Otoscopy, 823; Laryngoscopy, 825; The Pathologic Larynx, 825.		
	CHAPTER 30	
BRONCHOSCOPY AND ESOPHAGOSCOPY - - - - -		831
	CHAPTER 31	
PROCTOSIGMOIDOSCOPY - - - - -		835
	CHAPTER 32	
GASTROSCOPY AND PERITONEOSCOPY - - - - -		838

METHODS OF DIAGNOSIS

Part 1

PRINCIPIA DIAGNOSTICA

Chapter 1

LOGIC AND DIAGNOSIS

"The sciences stand in need of a form of induction which shall analyze experience and take it to pieces and by a due process of exclusion and rejection lead to an inevitable conclusion." Francis Bacon—*The New Organon, or Directions Concerning the Interpretation of Nature*.

I. DEFINITION

Diagnosis is defined by Webster as the determination of the nature of a disease. That "a" is important; we are dealing with a single instance, a single individual and his disease. No generalizations are involved, it is the application of the data of science to a specific case. Bernard Shaw's definition is a valuable expansion of Webster—"Diagnosis ought to mean the finding out of all there is wrong with a particular patient and why."

II. NATURE OF THE MENTAL PROCESSES USED IN DIAGNOSIS

Diagnosis is, of course, a mental process; but what kind of mental process is it? Obviously the diagnostician is making some kind of assumption about the universe. He assumes that the universe is one of law. Disease, the subject with which he deals, operates according to law. A single specific disease will therefore also operate according to law. The diagnostician may, nay indeed must, assume that if he detects a systolic murmur at the apex region of the heart it has a cause and that cause may be one of several different but perfectly definable things. Other parts of his examination tend to eliminate the ones that do not operate so that eventually he can conclude exactly what the cause of that systolic murmur is.

It must be evident that in this procedure the diagnostician goes through two mental processes, quite distinct from each other. The first is the accumulation of data. The second is reasoning from the data, in order to determine what they mean. In order for the second to be valid, the first must be accurate. The second process of reasoning from the data to the determination of the cause is carried out according to the laws of logic.

Dr. Richard Cabot (*Case Teaching in Medicine*) put the idea very clearly from the viewpoint of the student and practicing physician: "The most important lesson to be learned by every student of medicine is the art of recognizing the physical signs of disease—a displaced cardiac apex, a succussion-sound, an Argyll Robertson pupil, a malarial parasite. But these data have

to be interpreted. They do not crystallize spontaneously into conclusions. They do not arrange themselves in those significant groups which we call diseases. They have to be worked up into diagnoses by a reasoning process and this reasoning needs practice. A man may collect with accuracy and thoroughness the data of the history and the physical examination, and then find out that he does not know what they mean—what judgment can be based upon them, which of them are of primary and which of secondary importance."

"After the student has learned to open his eyes and see, he must learn to shut them and think."

"A considerable part of a doctor's life is spent in using techniques of one kind or another," writes Dr. Errett C. Albritton, in his laboratory manual, *Physiological Techniques*. "Not a small part of his time in medical school was spent in learning them. The distinguished cardiologist or surgeon who is guest speaker before the medical society, and the hard working practitioner who sits in the audience, are alike masters of their techniques. Yet to the training of the distinguished visitor, it would seem, something has been added. He is master of additional techniques that have contributed to leadership in his profession."

Those techniques are just the ones I purpose to discuss in this preliminary chapter—(1) the judgment of evidence and (2) reasoning according to the laws of logic.

III. NEED FOR CONSCIOUS APPLICATION OF LAWS OF LOGIC TO DIAGNOSIS

Several years ago, in the course of a clinic before a junior class of medical students, we reached an impasse and it occurred to me to ask—"How many of you have ever had a college course in logic?" In a class of about seventy-five individuals one raised his hand in the affirmative.

Now, the first comment that must be made on this situation is that it could never have happened in a medieval university. In that noble discipline of the *literae humanis* which those early institutions of culture imposed on and required of their matriculates, the first part of the Seven Liberal Arts, the *trivium*, consisted of grammar, rhetoric, and logic. The second part, the *quadrivium*, comprised arithmetic, geometry, music, and astronomy.

Looking at the subjects of the *trivium* let us note that they all deal with words. Words are the symbols of thought, the counters of intellectual intercourse. I do not know that I am prepared to go as far as Professor Watson and the Behaviorist school and say that thought is merely and only language. But though it is true that the phenomena of nature are entities and our thoughts about them may be entities divorced from words we at least have to use words to identify them when we wish to think about those entities or to communicate our thoughts to our fellows. So quite properly the *trivium*, the department of method of the medieval schoolmaster, dealt with words. *Grammar* presented the same subject matter it does today, except that it used Latin models: it dealt with reading and writing, the parts of speech, and the

proper construction of sentences. *Rhetoric* furnished the best models of composition: we know the exact list of "best books" which were studied at the Free Grammar School at St. Bees, Cumberland: they were the Catechism, Psalter and Book of Common Prayer, New Testament, Aesop, Cicero, Sallust, Caesar, Terence, Virgil, Horace, and Ovid. *Logic*, which was often called dialectic, dealt with definitions, propositions, syllogisms, and fallacies.

"But," I hear the objection, "what has the logic of a medieval university to do with us? Their curriculum knew nothing of science—even the astronomy of their quadrivium was mostly astrology—and they had no faintest conception of the problems of physics or biology or chemistry; in their day anatomy, physiology, bacteriology, and pathology were unborn. You say logic is a method, but their logic was Aristotelian logic, a dead thing, rigid and formal, totally incapable of application to the fluid and ever-changing problems of today."

Such a criticism could be presented only by one who is unacquainted with the development of modern logic. Unfortunately, and, as it seems to me, even tragically as it is neglected by the contemporary scientist, logic has grown and developed. It has developed a whole fresh set of applications to scientific thinking—the formulation of probability, of probable inference, of calculation of error, judgment of evidence, the usefulness of hypothesis and theorem to name only a few. Even the old Aristotelian categories of definition and fallacies have received entirely new elaboration.

Another criticism of my advocacy that logic should be required study for the present university student of science or medicine is that such a student knows, perhaps largely subconsciously, the principles of logic. A man cannot have matured sufficiently to have arrived in the second year of a course in medicine without knowing how to analyze the validity of an argument. This, I admit, is very largely true. I find in my experience in giving a course in logic to medical students that in the first session when I pose some preliminary question, they spot fallacies and recognize the reasons for the validity of sound arguments quite readily. But their focus on them is fuzzy. They recognize a perfectly formal, venerable Aristotelian fallacy, but they give it a name of their own which is much more awkward than the classic name, and it is pure torture to listen to them explaining exactly why a fallacy is a fallacy, or why an argument is valid.

Now why should we not lift this out of the realm of fortuitous chance, something students happen to pick up by accident with their sharp, bright brains and present it as a formal study, as did the medieval schoolmen—as a tool, as, indeed, the foundation of all study? I know by experience that it is perfectly capable of being so presented, and I believe it sharpens the medical man's thinking, it clarifies his intellect.

In the practice of diagnosis at least I am sure that equally fundamental with the acquisition of his skills, such as history taking, inspection, auscultation, urinalysis, blood counting, etc., it is to learn the methods of logic.

IV. OUTLINE OF LOGIC APPLIED TO DIAGNOSIS

A definition of logic should tell us its objectives and its limitations. Creighton's textbook opens with the statement: "Logic may be defined as the science of thought." And Sellar's modifies that to "science of correct thinking." I cannot agree with this. Logic is not a science. A science is a body of knowledge. Logic is a method—like percussion or piano playing. It is a means to an end. The *Port Royal Logic*, published in 1662, does better with its opening definition—"Logic is the art of properly conducting one's reason in the knowledge of things."

I like Professor Castell's definition best of all:

"Logic is the study of argument. Argument is discourse containing inference (i.e., not debate). Inference is the transition from data to conclusion."

I will venture on a definition of my own:

Logic is the attempt to formulate methods of reasoning in order to establish validity.

Note that in this definition I do not say that the aim of logic is to arrive at truth or certainty. The best we can often make of a problem is to arrive at probability or to compose a hypothesis. Sometimes the nature of the problem is such that we can say it is insoluble—as squaring the circle, or in the present state of our knowledge, the cause of neoplastic disease. But by the application of logic we should be able to tell whether the conclusion we have reached is a certainty, a probability, a probable inference, a choice of two or three decisions of equal probability (as often happens in diagnosis), or that with the means at hand we must leave it in what has been called the agony of suspended judgment. To include all these conclusions comprehensively I submit the word *validity* as appropriate.

The basis of all logical inference may be abstracted thus:

IF P THEN Q

P represents the data (premise) and *Q* the conclusion. *If* and *then* the inference.

Every scientific or medical or diagnostic argument can be reduced to that formula. It can be analyzed, examined, confirmed, or refuted on any one of its terms: (1) *If*; (2) *P*; (3) *then*; (4) *Q*.

Such in the starkest outline is the result of the twenty-four hundred year long struggle of mankind to discipline his thinking.

On the assumption that this is the basis for precise and valid thinking, let us see if we can fit into it the steps in reasoning which constitute a diagnosis.

P the premise, is represented by all the data which the diagnostician accumulates about the condition of a patient—history, physical signs, laboratory signs. This, of course, requires no higher intellectual processes at all: it is simply a matter of technical skills, accurately applied, and correctly set down. Of course a major proportion of the time a student spends in medical school is devoted to the acquisition of these skills, and during his entire professional

life he continuously adds to, improves, and sharpens these skills. And indeed it is of the most fundamental importance that he should do so. Because if *P* is false, if the data are inaccurate, the conclusion—the diagnosis—must be false.

The second step I assume to be an evaluation of the data just accumulated. The diagnostician eliminates the information which has no bearing on the case. He assigns to the various symptoms and signs a relative value or importance. A few he conceives to represent the heart of the problem. Others he conceives to be of secondary significance. Some of these are corollaries of his main group of presenting symptoms and signs: some do not seem to fit in or are really contradictory in nature. The diagnostician must attempt to resolve the contradictions, or, if he cannot, make a reservation or note of exceptions. At any rate he comes out with an abstract, a sort of condensation of the clinical picture of his patient—let us say a syndrome.

Suggestive questions which the diagnostician may ask himself in order to resolve the chemical data of his individual patient into a syndrome are:

Is the disease organic or functional?

If organic, is it infectious, neoplastic, degenerative (especially the great common group of diseases dependent on arterial degeneration), allergic, due to nutritional or endocrine disturbance? Is it pregnancy or any of the complications of pregnancy?

If functional, is it physiologic, such as migraine, epilepsy, asthma, avitaminosis, or due to personality or a neurosis or a psychosis?

What organ or system is involved primarily?

This second step requires judgment and experience. There is no substitute for their acquisition except time, application, and practice.

The third step I conceive to be the setting up of a list of all the possibilities of what this syndrome can be. This requires a knowledge of pathology, or that part of pathology which we call clinical medicine. I submit that our knowledge of pathology is now sufficiently extensive and comprehensive that it is possible, confronted with a specific case, to make a list of all the diseases that could possibly be the fundamental cause. To do so requires on the part of the diagnostician knowledge and, let us say, memory and practice. "Didn't think of enough things," as my friend, Dr. P. T. Bohan, has often said to me when we were analyzing a mistaken diagnosis. In Part II (*Symptoms*) and Part III (*Physical Signs*) of this book I have endeavored to make a complete list of all the diseases which might be present when a specific symptom or sign presents. This was planned in this way to help the diagnostician in this step—i.e., in making a list of all the possibilities. It is probably not complete but the practitioner can add to it as his experience dictates.

The fourth step is by inductive reasoning to fit the particular syndrome which the individual patient presents as nearly as possible to the proper syndrome or disease type, among all the disease types the diagnostician has listed under step three. This is a process of inductive logic or reasoning, it repre-

sents the *then* of the "If P then Q" formula, and is arrived at by the application of what is known in inductive logic as the canons of agreement, of difference, and of joint agreement and difference. Sometimes the application of the Canon of Residues is required. These canons I shall discuss below.

Perhaps for confirmation the problem may finally be thrown into deductive form and tested by syllogism. But this step I would not insist on.

Diagnosis is a problem in induction, going from particulars to a generality. The individual patient presents the particulars—his symptoms and signs. These are resolved until they fit into some part of the general known data of pathology. Our knowledge of pathology is now so wide that, with a few exceptions, we can make a list of all the known possibilities, all the categories into which any patient can possibly fit.

STEPS IN DIAGNOSIS

1. *Technical skill.* Accumulation of all the data about the individual patient.
2. *Judgment and experience.* Evaluation of the presenting symptoms and signs in the individual patient. *Pathognomonic*—consider the relative value of symptoms, physical signs, laboratory signs, x-ray, etc.
3. *Knowledge—Differential diagnosis.* Make a memorandum of all the diseases or syndromes known which are in any way similar to the syndrome which the patient presents.
4. *Reason.* By the canons of agreement, difference, joint agreement and difference and residues, and by probable inference and theorem fit the individual syndrome to the disease type.
5. *Summation.* With the conclusion as to the correct diagnosis before you, throw the argument into syllogistic form in order to test it:

This patient has ABCD
Disease X has ABCD
Therefore this patient has Disease X

There is no claim on my part that there is anything new in this outline which I suggest for a model or scaffolding of diagnostic thought. Indeed, it is no more than an expansion of the practice embodied in the venerable clinical phrase "Diagnosis by exclusion." It is used by all diagnosticians in every mental act of diagnosis no matter how simple and obvious or how difficult and complicated the case. Take the snap diagnosis. "He has Parkinson's Disease," you say to yourself, noticing a figure on the opposite side of the street! Have you abandoned all thought processes in coming to that sudden decision? Not at all. Behind that lightning, rapid judgment are all the mental processes I have put down above as the necessary steps in diagnosis. You have noted the man's age, the mask face, the pill-rolling tremor of the hands, and the lurching gait. Those are the essential data of observation. Your catalogue of pathologic possibilities tells you that only Parkinson's disease and the post-encephalitic syndrome can be responsible. Age rules out the postencephalitic syndrome. Such are your reasoning processes, rapid, but a complete résumé of what I have just set down.

V. RÉSUMÉ OF THE FORMS AND PRINCIPLES OF LOGIC

I wish here to present an outline of the main formulations which have come to be called logic, especially as they are applicable to diagnosis and scientific method. I believe, for purposes of clarity, the subject can best be approached historically.

The Sophists

The prosperity which came to Athens after the Persian Wars developed a group of teachers who sold their advice, or system, to their pupils. It was a system of argumentation with the application of apparently logical rules to any of the problems of life. They did not seek to teach truth as an object, or inculcate a love or reverence for scientific truth. Rather they taught how to give plausible reasons for any action or way of life. They were despised by Socrates and Plato because their system was prepared to make "the worse appear the better reason." It was not essential to have any real knowledge of a subject in order to argue about it. Their system is known as skepticism. They came to the conclusion that it is impossible to find any fixed standard of truth, or of right and wrong. They were called Sophists. Prominent Sophists were Protagoras (444 B.C.) and Gorgias (427 B.C.).

(A typical Sophist argument is *The Litigiousus*)

Protagoras, the Sophist, made an agreement to teach Euathlus the art of pleading, guaranteeing that he would win his first case: his fee to be paid half when he was fully instructed and the other half when he had tried and won his first case. Euathlus put off trying a case in court, so Protagoras sued him offering the argument:

If Euathlus loses this case he must pay me, by the judgment of the court.
If he wins it he must pay me by the terms of the contract.

But he must either win or lose it.

Therefore he must pay me in either case.

Euathlus offered the following rebuttal:

If I win the case I ought not to pay by the judgment of the court. If I lose it I ought not to pay by the terms of the contract.

But I must either win or lose it.

Therefore I ought not to pay.

Socrates (469-399 B.C.) opposed the Sophist doctrines especially in regard to their loose ideas of right and wrong. He scorned the way the Sophists accepted money from the rich in order to furnish them with arguments which would enhance their wealth and allow them to lead a life of pleasure and licentiousness with a clear conscience. He taught every one who would care to listen. Some Socratic dialogues directly attempted to refute the Sophists in the field of morals: *Protagoras* on virtue as knowledge; *Mexenus*, a satire on oratory; *Charmides* on virtue as self-knowledge; *Gorgias* on absolute right and wrong. After Socrates' death Plato (427-347 B.C.) devoted dialogues to the sub-

jects of the Sophist view of knowledge; *Theaetetus*, one of the most splendid, on how to define knowledge; *Phaedrus* on rhetoric; *Euthydemus* on the one and the many.

Socrates and Plato denied that the common standard of action and thought is to be found in the senses. Every man as a rational being carries in his mind a concept of reality as to truth and right and wrong.* It can be brought out even if he is unaware of it, by inductive logic. Knowledge arises from thinking.

Plato, through his mouthpiece Socrates, started logic on its proper path by insisting on the fundamental importance of definition. Many of the dialogues are simply exercises in arriving at the definition of a term. Every beginning logician should read a simple one, such as the *Euthyphro*. Its subject, which is piety, may not appeal to the medical man except that it would be fairer to translate it *sincerity* or *character*, but the subject is of no matter: the importance of the dialogue is the relentless method by which Socrates tried to clarify his companion's, Euthyphro's, idea of what piety is.

In order to point up the fundamental value of definition, I will abstract the Platonic dialogue *Theaetetus*.

In the *Theaetetus* Plato attempts to define, or rather he attempts to examine the definitions of something far more important to us—the nature of knowledge. Every physician, indeed every thinking man, should want to acquire a clear conception of what knowledge is. Suppose before you read Plato, or before you examine my abstract of the *Theaetetus*, hereunder appended, you close the page and try to clarify your ideas of just what it consists to know something. That will prepare the way for Plato's suggestions.

In the *Theaetetus* Socrates is found questioning the youth Theaetetus to tell what he means by knowledge. Theaetetus begins by mere enumeration—a shoemaker has knowledge of making shoes, and a flute player has knowledge of playing the flute. "Oh! yes," answers Socrates, "but is there not something that is common to all of these isolated pieces of knowledge?" So Theaetetus, after some thought, replies, "He that knows perceives what he knows and so far as I can see at present, knowledge is perception." It is the reply of Berkeley—that we know what our senses tell us. We see a tree, and we feel it, and we smell it, and we taste its leaves, and we hear the wind in the branches and that is all we know of a tree. But the answer does not satisfy Socrates. Our senses may fool us. "The same wind is blowing and yet one of us may be cold and the other hot." We dream of a tree and all these sensory images come to us in the dream, yet they have no reality, only a memory. The insane have hallucinations. In thinking about those sensations the soul is considering the matter, discriminating and comparing, and forming a judgment. Animals are as capable of sensation as men, and babies as adults, but sound convictions about reality and value are attained by us only with time and by pains and education. "Knowledge" is not to be sought for in the affections of our sensibility, but in the mind's reflection upon them. And this finally

*"Goodness is the health and beauty and well-being of the soul, while evil is its disease, deformity and weakness." Republic.

proves that knowledge is not the same as sensation alone. What of abstractions like time, space, right, wrong, truth—we do not learn to know of these through our senses.

Theaetetus, in answer to these arguments ventures an amended definition and says that knowledge is true opinion, or is perception expanded by judgment. But Socrates wants to know what this concept of opinion or judgment is. *A man may have a false opinion. He may make an unsound judgment.* He may possess knowledge without having it, as he may possess a coat without having it on. "As you may suppose a man to have caught wild birds and to be keeping them in an aviary which he has constructed at home: he possesses them but he does not have one until he has caught it and taken it in his hand. Let us suppose the birds are kinds of knowledge and when we were children this receptacle was empty: whenever a man has gotten and detained in the enclosure a kind of knowledge he may be said to have learned it, but these are in his memory and he knows a thing only when he has caught it and is handling it." So we may "possess" a certain knowledge, and yet when we want to use it we may not be able to recapture it. We may capture the wrong piece of knowledge, and this will be the case of the man who makes a false judgment.

Theaetetus makes his contribution to the image of the aviary—"Perhaps, Socrates, we may have been wrong in making only forms of knowledge our birds: whereas there ought to be forms of ignorance as well, flying about together in the mind: and then he who sought to take one of them might sometimes catch a form of knowledge and sometimes a form of ignorance: and thus he would have a false opinion from ignorance, but a true one from knowledge about the same thing."

The consideration of which, that the man who acquires knowledge learns to differentiate ignorance or false opinion from true judgment leads Theaetetus to attempt his fourth and final definition of knowledge that it is "true opinion combined with reason." In other words to "perception" has been added "with judgment (true opinion)" and finally "combined with reason"—or, as some translations have it, "after discourse." The word in the original is "logos" which is the same as St. John's "The Word." In the Platonic philosophy logos is world order. The meaning is clear although somewhat mystical. Knowledge is perception expanded and clarified by judgment, based on the conception of experience with the world order.

Socrates is not entirely satisfied with this although he admits it has clearly advanced the argument. He wishes the logos cleared up and properly so, a modern disciple would agree. The dialogue ends, as all Platonic dialogues do, with a more or less negative conclusion. But, again, as in the case of all the Platonic dialogues, how can one read and follow it without an immense clarification of thought?

Aristotle (384-322 B.C.) took over Plato's somewhat nebulous ideas about correct thinking, added to them, sharpened them, and molded them into a formal and definite system. This part of his writings is known as the *Organon*, and is

divided into the *Categories*, the *Prior Analytics*, the *Posterior Analytics*, the *Interpretation*, the *Topics*, and the *Sophistical Elenchus*, or *Sophistical Refutation*.

In the *Categories* Aristotle listed all the things that can be said about any object or objects, all attributes of any subject under discussion, all the ways we have of thinking about the kinds of realities. They are:

1. Substance—e.g., a man.
2. Quantity—e.g., one.
3. Quality—e.g., white or abstract.
4. Relation—e.g., double.
5. Place—e.g., in the Lyceum, or in the morgue.
6. Date—e.g., today.
7. Position—e.g., sits.
8. State—e.g., is shod.
9. Action—e.g., cuts.
10. Passivity—e.g., is cut.

Even more his genius for clear analysis is seen in his classification of terms and definition.

Terms are:

- I. (a) Singular, (b) general, (c) collective.
- II. (a) Positive, (b) negative, (c) privative.
- III. (a) Abstract, (b) concrete.
- IV. (a) Relative, (b) absolute.
- V. (a) Extensive (denotation), (b) intensive (connotation).

Perhaps our modern term for categories and terms is classification.

Definition.—A definition should:

1. State essentials: state the essential property of the definendum.
2. Not contain the name of the thing defined—i.e., "Goodness is that which marks the conduct of a good man" is not a definition.
3. Be exactly equivalent—i.e., "A circle is a figure whose radii are equal" is too broad because it includes spheres.
4. Not be expressed in obscure or figurative language.
5. Be affirmative and not negative.

Dichotomy.—

A subdivision of the subject of definition is dichotomy, or division. It is important in science because it carries the principle of classification. By definition a triangle is "a geometrical figure formed by three lines intersecting by twos at three points." By division, or classification, triangles are scalene, isosceles, right angle, or oblique. A librarian classifies his books by a series of dichotomies. Linnaeus decided after study that in order to describe plants he must divide from the other parts of the plant, the sexual organs, because only in this respect could he classify them into species, genera, and orders.

The rules of division are that it should:

1. Be made on differences in the fundamental nature of the divided δ
2. Be based on a single principle.
3. Be mutually exclusive.
4. Be exhaustive.

Taken together these constitute the law of the excluded middle.

They are so obvious as not to need any further elucidation or illustration.

This subject of definition seems to me very much alive today and directly applicable to diagnostic thinking. As I go over diagnoses with students, or read case histories in the literature, I find constantly that the difficulties which may exist, the fallacies which I persuade myself I detect, or the soundness of the argument, is constantly dependent on the requirements of exact definition. "Define your terms" is the oldest and still most constant demand of the logical mind and the most usual way to agreement.

As an illustration I recall a conversation I once had with Dr. Raymond Pearl, the biologist and biometrician. The subject of the relation of alcohol to cirrhosis of the liver came up and I said that I thought the relationship was definite and causal. He said the first thing they disproved in his classes in medical biometry was such causal relationship. I recited some case histories intended to show that data were very unreliable and also said that every acute clinician I ever knew, including William Osler, Sir Humphrey Rolleston, and Alfred Stengel, were certain of the relationship. Somewhere in the argument he said, "Well, I am a pathologist. I know what pathology is." To which I replied, "O.K. Tell me exactly your definition of cirrhosis of the liver." At which he began descriptions which showed he included all sorts of hepatitis and liver cell degeneration, including the purely theoretical Hanot's cirrhosis and the liver degenerations that are found in the wild animals. When I pointed out my dissatisfaction with such terms, we got a good deal closer together than we had been.

This whole subject of definition has become in our own day the focal point for a very lively discussion. It has indeed been lifted to the dignity of a science of its own, called semantics. And since a very distinguished member of our guild, Sir Clifford Allbutt, was among the founders of the movement, we will notice it here.

The first use of the term semantics and the first presentation of semantic doctrines was in Michel Breal's *Essai de sémantique* in 1897 (translated into English in 1900). Lady V. Welby wrote for the eleventh edition of the *Encyclopaedia Britannica* an article "Signifies" which she defined as "the science of meaning, or the study of significance, provided sufficient recognition is given to its practical application as a method of mind, one which is involved in all forms of mental activity."

Among the few philosophers who took Lady Welby seriously were C. K. Ogden and I. A. Richards who published a book, *The Meaning of Meaning* in 1923. (They later constructed a list of words for "Basic English.")

In the meantime Clifford Allbutt, without being aware apparently of Breal's *Essai de sémantique*, had in several writings and addresses (*Notes on the Composition of Scientific Papers* 1905; *Words and Things: An Address to the Students' Physical Society of Guy's Hospital*, "Lancet, Oct. 27, 1906), plead for a classification of medical terms and exactness of expression in medical writing. In thinking, he averred, medical men construct "thought cages for themselves." A passage from the address on *Words and Things* is worth quoting:

"Some of you, who have heard my teaching before must forgive me if I repeat my insistence that the name of a disease is not, as it is continually regarded, a thing. There is no such thing as typhoid fever, as angina pectoris, as spleno-medullary leucemia, and so forth; the things so-called are Wilkinson, Johnson, and Thompson, who after their kinds are afflicted not alike, but within such limits of similarity as to lead us to class them together and to form a general conception of them. Yet still we overhear at learned societies physicians whose shoe latches I am not worthy to unloose contending, even with heat, whether this name or that is a 'morbid entity.' Now 'entity' is anyway a bad word, as words can be bad; it was born badly, and has kept bad company. It was born to signify that reality of substance which was once supposed to underlie abstract names, and in these ontological circles it has moved ever since. If we are to speak at all of 'entities' in disease, these must be not the names nor even our concepts, but the things—the thing Thompson, and the thing Wilkinson in certain phases of their being. The moment we depart from these objects we desert the names of things for the names of abstractions in which no entity can lie, the name being but a label to denote a somewhat arbitrary and ideal group of characters, or type, never perhaps manifested in nature as a whole, but to which certain individuals are continually approximating. I do not pretend for a moment that we can do without abstractions; without them reasoning would be impossible; our safety lies not in avoiding reason but in being quick to recognize the tendency of ratiocination to carry us away from the only pregnant subjects of reason—namely, from things, with which reason should never cease habitually and steadily to concern itself.

"It is only by examples that discussions such as this can be made clear. In epilepsy, for instance, we observe a vast number of persons attacked in modes not identical but similar, modes, however, the features of which shade off by insensible transitions into the features of other groups of symptoms; so that our concept is not of an absolute but only of a relative uniformity. This we should remember when we use the name; as we remember that when we call a certain group of stars Orion, or Charles's Wain, that there is no rigid division between these star groups and those of the neighbouring constellations. Now epilepsy is no more an entity nor an absolute idea than Orion; it is the name of an arbitrary group, so separated for the convenience of the thinking faculty of finite beings. So far as to the nonentity. But, as I have hinted, we proceed, having set up our entity, to treat it as savages treat their images, to shake and to harry it at our caprice. Surely, having accepted a name for a group, we ought to keep to it; and yet we find our friends daily calling widely different concepts by the same label of epilepsy; for instance, puerperal or uraemic convulsions, Jacksonian convulsions, certain insanities, and so on, events so very different both in nature and grouping that, if we give them also the same name of epilepsy, we shift our things without shifting our labels. Or, again, consider angina pectoris; if there be a uniformly recurrent group of clinical features it is that for which this name was invented; yet we shift the label about, now to spasms of neurotic women, now to vague and casual cardiac pains or discomforts consistent with almost

any kind of heart disease. Most grotesque, perhaps, are the 'pseudo' compounds, such as 'pseudo-angina,' 'pseudo-leukaemia,' and the like; think for a moment of calling scarlet fever 'pseudo-measles'! Yet it is not very long since these two maladies were distinguished. It were but too easy for me to prolong such a list of ambiguities due to shifting our labels, or to shifting our concepts under the labels; but these must suffice. Remember that when it is asked if such and such a group of systems be a 'morbid entity' or not, that since the day of William Ockham we have given up entities, that the question is now one only of convenience of reason; but that when we have once agreed to give a certain name to a certain morbid series of events—arbitrarily agreed, that is—then we must stick to our label; for if the label is to be shifted about, or the things under it shifted, all accurate reason comes to an end. The best labels for diseases are such names as epilepsy, measles, leprosy, Graves' disease, and the like, which, having no attachment to hypotheses, are readily carried to new anchorages. One may walk dryshod from one disease to any other, yet, on the other hand, it is no less true that, because of the large differentiation of his parts and organs, in Man his morbid processes tend to a corresponding uniformity of recurrence; his symptoms recut in similar groups and orders—symptoms-groups or syndromes as they are called by certain nosologists who are desirous of some name finer than the old term 'disease,' or are possessed with the tenacious notion that a disease is a real something in itself. But diseases are not even species, such as cats and toads, but abnormal, though not altogether irregular, behaviors of individuals.

"Our debt to the morbid anatomist is so profound that in our gratitude we are forgetting that the pathologist is not a clinical physician; indeed, that so long as he is denied right of access to the living patients in the wards he is becoming more a man in a balloon. His laboratory is full of things no doubt, and hitherto he has dwelt soundly in things; but chiefly in dead things, not in things at work; yet our only real things are processes. Yet the pathologist has been largely concerned in undermining our clinical concepts; and so invaluable a service has he done us in compelling us to occupy ourselves with things rather than words that we are gratefully disposed to believe he can do no wrong. Hence, without protest, we have allowed him to relabel some of our things with his labels: often to our advantage, but at least sometimes to our error. For instance, the pathologist has seduced us into allowing him to use the label of arteriosclerosis as the name of a disease. Now if for the physician a disease is a series of symptoms recurring with such uniformity that we think it convenient to distinguish it with a name, arteriosclerosis is not such a series; it is not a series of symptoms at all; it is a result, a statical result of foregone symptoms, probably of more than one series, and, if so, probably itself a compound name even in pathology. The physician who recognises the imperative duty of dwelling in things ought to guard himself from being supposed to mean only things that stand still; his sphere is on the contrary with things in motion; he is master of dynamics."

As for the rest of the literature on semantics the diagnostician need not, if he wishes to take my advice, waste any time on it. Some of the treatises, such as that of Stuart Chase, are sober and sensible enough, but there is in nearly all writings on the subject a tendency to exaggerate the importance of words. One cannot see that semantics is such a great departure from Aristotle's warnings against fallacies based on ambiguous terms. Nor can one see the "salvation in semantics" that is insisted upon by Count Alfred Korzybski in his work *Science and Sanity: An Introduction to General Semantics*. (Second Edition, Lancaster, Pa., 1941, Science Press.)

I hardly think it is necessary for any student of logic in diagnosis, or indeed in science, to study Korzybski's general semantics. The work is characterized by intolerable diffuseness, repetition, and hypersensitiveness to adverse criticism.

Fallacies of Definition.—In all treatises on logic there is a chapter devoted to fallacies. It is a very interesting subject. Fallacies are the pathology of logic. Much of the space devoted to them by the academic logicians is taken up with the fallacies of debate, such as the argument *ad hominem*, so perfectly exemplified in Shakespeare's rendition of Mark Antony's oration over the dead body of Caesar. These fallacies are not often met in medical literature or diagnostic thinking and we will not notice them.

The fallacies of definition are, however, in my observation, the most frequent causes of mistakes which the practicing physician makes.

Most frequently he violates one or another of the five requirements of a definition as given above. The inexperienced diagnostician drops into ambiguity.

But far and away the commonest and most serious fallacy, the most fraught with dire consequences to his patient which the diagnostician makes is one for which the formal logicians have never coined a name. I therefore had to set myself the task of naming it. Among the words I thought of were "faking," "fabricating," "concocting," "perversion"; I finally settled on *faction*. It is derived from the adjective factitious, which is defined as "made by art, in distinction to that made by nature." It is the habit many doctors have of talking about a pathologic condition which does not exist in nature. They go around with a kind of faery pathology in their minds which they make up as they go along. They remind me of the simile of the deist, or it might have been the philosopher, who was likened to a blind man looking in a dark room for a black cat which wasn't there.

Robert Hutchinson (*Brit. M. J.*, March 3, 1928) has an anecdote which points up this source of error, and indicates how serious are the dangers involved.

"I remember a patient being sent to me some years ago by a practitioner who rather prided himself in being 'up-to-date,' with a diagnosis of 'albuminuria, the result of alimentary toxemia.' He sent with the patient the most elaborate analysis of the stools and most detailed reports on their bacterial flora, but he had quite failed to notice that the patient had advanced mitral disease with commencing heart failure, and that oedema of the feet and congestion of the bases of the lungs were present as well as the supposed 'toxic' albuminuria."

Dr. Richard C. Cabot years ago (*J. A. M. A.* 59: No. 26, Dec. 28, 1912) drew up a partial list of items of this kind.

"'Acute gastritis' is a rare disease in adults. As a rule appendicitis, or gallstones is the correct diagnosis.

"'Chronic indigestion' is usually a mistaken diagnosis, the actual condition being peptic ulcer, pulmonary tuberculosis, constipation, or cancer of the colon.

"'Bronchitis' usually proves to be phthisis, bronchiectasis or bronchopneumonia at autopsy or in the outcome.

" 'Asthma' beginning after middle life is usually symptomatic of cardiac or renal disease.

" 'Unresolved pneumonia' is frequently a mistaken diagnosis, the real disease being empyema.

" 'Malaria' is often given as the diagnosis in cases of phthisis, hepatic syphilis, hepatic abscess and urinary infections.

" 'Typhoid fever' in a patient's history may mean tuberculosis or latent sepsis (septic endocarditis, suppurative nephritis, etc.).

" 'Rheumatism' has sometimes turned out in my experience to mean aortic aneurysm, cancer of the pleura, tabes dorsalis, osteomyelitis, spondylitis deformans, bone tuberculosis, syphilitic periostitis, lead poisoning, morphine habit, alcoholic neuritis, trichiniasis and gonorrheal infection. 'Rheumatism' is one of the most dangerous of all diagnoses to the conscientious physician.

" 'Cystitis' is usually not a disease. It points to disease below the bladder (stricture, obstructing prostate, etc.), or above it (renal tuberculosis, and other renal infections) as its cause.

" 'Hemorrhoids' often mask cancer of the rectum.

" 'Neurasthenia'—the real disease almost always shows itself in youth on the basis of congenital tendencies, though, like tuberculosis, it may be roused into active progress by any prolonged strain, mental or physical. When it appears after middle age it is almost always a symptom of organic disease—such as dementia paralytica, chronic nephritis, arteriosclerosis, myxedema, hyperthyroidism or phthisis."

I miss from Dr. Cabot's list the term "neuritis" used to designate any pain in the extremities, although there may be little if any evidence that an inflammation of a peripheral nerve is present, or even that a nerve is involved at all.

The vogue of vagotonia and sympathicotonia is dying out, but it is still found in some sloppy dossiers although there was never any good evidence that vagotonic individuals had particularly sensitive vagus nerves or that either term applied to any patients save those with a functional neurosis.

To Dr. Cabot's list it is imperative to add "chronic appendicitis" as a term that does not mean anything yet is often used because it is cheaply satisfying. No one can read Dr. Arthur E. Hertzler's brilliant little essay on chronic appendicitis (*Am. J. Obst. and Gynec.* 11: No. 2, February, 1926, and *J. Missouri M. A.* 28: No. 12, December, 1931) and refrain from cringing whenever afterwards he hears the term mentioned. Wrote Dr. Hertzler:

" 'Epigastric disturbances plus tenderness in the appendiceal region equal chronic appendicitis' is an unfortunate aphorism that has gone around the world. This may be presented as a fair concept of the disease by those competent surgeons who make such a diagnosis. I note with pain that a 'model history' sent out by the American College of Surgeons has to do with 'a typical case of chronic appendicitis.' It is broadcasting from high places such as this that does the mischief. It is impossible to present anything like all the curious clinical symptoms that have been ascribed to chronic appendicitis. One writer records 'a series of one case' of angina pectoris due to and relieved by the removal of a chronically inflamed appendix. Another recognized a 'chronic nervous appendicitis' and cured seven cases. The clinical picture he presents is 'nervousness, headache, melancholia, irritability, insomnia, dizziness, general weakness, poor appetite, inability to think clearly and habitual

constipation.' I become afflicted with all these symptoms whenever I contemplate the picture of chronic appendicitis."

"Conclusions:

"1. Fibrotic changes in the appendix, no matter of what degree, are not attended by clinical symptoms.

"2. The anatomic structure of appendices commonly removed under the diagnosis of chronic appendicitis show no variation from the appendices of individuals suffering from no abdominal complaint whatever.

"3. The minimal changes alleged to be present in cases of so-called chronic appendicitis are wholly inadequate to explain the symptoms ascribed to them considered in the light of like changes in other organs of the body.

"4. Mere alleged relief after the removal of the appendix of symptoms is not sufficient to prove that the appendix was the cause of the symptoms.

"5. The vast majority of patients so operated on do not even claim relief of their symptoms."

DEFINITIONS DUE TO EMOTIONAL THINKING

(THIS IS A FORM OF FACTITION)

One would hardly stoop to suppose that a man of science would be guilty of emotional thinking. But let me quote from a very sound and beautifully written book by William R. Houston, *The Art of Treatment* (The Macmillan Co., 1936). In discussing asthma he comments on the divergent views held and refers to a number of *The Practitioner* in 1929 which was entirely given up to a symposium of articles on asthma.

"If a student were to encounter one of these articles from an eminent hand he might accept the conclusions offered as final and authoritative. Since the articles are not isolated, but in juxtaposition, an effort at analysis and correlation cannot be escaped. The opinions are so much at variance that one conclusion that might be arrived at is that of Sir Humphrey Rolleston. In reviewing the very antagonistic viewpoints that are set forth he suggests that as in the case of epilepsy we now speak of the epilepsies, so in the case of asthma we speak of the asthmas."

In these articles the authors express these separate views:

1. A. F. Hurst. The cause of asthma is the constitutional factor, biochemical in nature, perhaps of endocrine origin.
2. James Adams stoutly affirms that asthma is a toxic nervous condition.
3. Alexander Francis considers the notion that asthma is due to hypersensitiveness is merely the latest fashion.
4. Professor W. E. Dickson thinks that asthma is a habit.
5. Sir William Wilcox says, "Search for occult sepsis."
6. Sir James Dundas-Grant states that operations on the nose with a very thorough removal of the nasal septum are the only treatments that offer any prospect of cure.
7. James Freeman emphasizes that asthma is due to a discharge of a histamin-like substance by trauma.
8. J. André, of the famous asthma resort at Mont-Dore, France, favors the digestive method of desensitization by peptone therapy.

9. Professor W. Storm von Leeuwen puts all his patients in an allergen-free chamber.

On this conglomeration of inconsistencies Dr. Houston comments: "These various approaches to the problem of treating asthma are given to illustrate not merely the problems of asthma, but the difficulties to be overcome in making substantial progress in clinical medicine. A man, having achieved some therapeutic success by a given method, becomes emotionally biased towards that method. He depends upon it in the same way that he builds up defense reactions for his own ego." (*Italics mine, but what a reflection on the vaulted "science" of medicine, or on what is thought to be scientific thinking.*)

Deduction

PROPOSITIONS AND SYLLOGISMS

Aristotle, in his analysis of the laws of thought, after considering categories, terms, definition and division, continued by considering how terms are arranged in the form of propositions and how propositions should be arranged to present a valid argument, which he decided was in the form of the syllogism. This made up the process of deductive logic and held men's minds until the growth and complexity required a new mode of thought for the investigation of nature, induction.

Deduction is arguing from a general thesis to a particular case,

All men are mortal.
Socrates is a man.
Therefore Socrates is mortal.

is the fundamental example of deductive logic. Deductive logic does not have any place, or at least much place, so far as I can see, in the reasoning processes of diagnosis. Diagnosis is, as we have noted above, an inductive process: reasoning from a particular set of data (the symptoms and signs of an individual patient) to a generality (a general disease process). Deduction is used in therapeutics and in the design of experiments for scientific research. I therefore am not under the necessity of presenting the nature of propositions and syllogisms in the detail in which they are described in the textbooks on logic.

A proposition is an expression in words of an act of judgment. It employs two terms, a subject and a predicate, connected by a copula or verb.

Propositions are:

Categorical or conditional.
Have to do with quantity and quality:
Affirmative or negative—quality.
Universal or particular—quantity.

Universal	{ Affirmative—All A is in B.	A.
	{ Negative—No A is in B.	E.

Particular	{ Affirmative—Some A is in B.	I.
	{ Negative—Some A is not in B.	O.

If terms are included they are called *distributed*.

If terms are not completely included they are called *undistributed*.

In A. the subject is distributed, the predicate undistributed.

In E. subject and predicate are both distributed.

In I. subject and predicate are undistributed.

In O. subject undistributed, predicate distributed.

Inferences may be made from any valid proposition. They may be either mediate or immediate.

Immediate inferences arise from *opposition*, *obversion*, *conversion*, *contraposition*, or *inversion*.

These are diagrammed in the famous figure I have reproduced from the section on logic of the Margarita Philosophia and have been so diagrammed in every textbook on logic since.

As an illustration, the immediate inferences from the proposition "all men are fallible" are: "no men are infallible," "no infallible beings are men," etc., etc.

Syllogisms.—

The syllogism is a method of inference of one proposition from another.

The typical syllogism has (a) a major premise, (b) a minor premise, and (c) a conclusion. It is valid when (1) the middle term is distributed at least once (it may be distributed twice) and is not ambiguous; (2) no term which is undistributed in the premise is distributed in the conclusion. (Illicit process of the major term, illicit process of the minor term.)

Complex syllogisms are *hypothetical* or *disjunctive*.

The *Dilemma* is a form of syllogism in which the major premise is composed of two hypothetical propositions.

Dilemmas are (a) simple constructive, (b) complex constructive, or (c) destructive.

Escapes from the dilemma—(a) grasping the horns, (b) escaping through the horns, or (c) rebuttal.

Sorites are syllogisms which have more than three propositions.

Enthymeme (in the mind) is a syllogism with one of its premises suppressed.

In the formal treatises on logic exercises on syllogisms are presented at great length. There have been devised many "moods" of the syllogism. The "All men are mortal: Socrates is a man; therefore Socrates is mortal" was regarded by Aristotle as the perfect syllogism. There are others less perfect, and these constitute different moods. I cannot see that these exercises are applicable to diagnostic thinking, nor has my experience with them convinced me that they train the mind, so I will not take up space to set them down here.

The implicative syllogism, however, may be useful in the step in diagnosis which I have called summation. The implicative, or hypothetical syllogism, is a deduction based on the supposition (or implication) that the primary proposition is true.

Example: If the laws worked out by economists are true, the causes of poverty can be determined. But if those laws are not true, our efforts to determine the causes of poverty are in vain.

In graphic form for deductive diagnosis the implicative syllogism appears in this form:

If the patient has Disease X, he will have symptoms and signs F, G, and I.

If the patient does not have Disease X, he will not have symptoms and signs F, G, and I.

If the patient has F, G, and I, and W, will he or will he not have Disease X?

The patient has F, G, I, and W—so?

Fallacies of Deductive Logic.—

A. SYLLOGISTIC.—The first four apply only to the syllogism.

Illicit Process.—This applies to syllogistic reasoning. It may be illicit process of the major term, illicit process of the minor term, or illicit conversion or obversion. If a syllogism is not proved by means of the premises, it is false. Example of illicit process of the major term "All rational beings are responsible for their actions; brutes are not rational beings; therefore brutes are not responsible for their actions."

Example of illicit process of minor term:

"All good citizens are ready to defend their country.

"All good citizens are persons who vote regularly at elections.

"Therefore all who vote regularly at elections are ready to defend their country."

Illicit process of conversion and obversion is to reverse the conclusion of a syllogism—"All brave men are generous" does not mean "All generous men are brave."

Undistributed Middle.—In this fallacy the middle term of the syllogism has the same subject as the first premise—i.e., "All babies are bald; all babies are noisy; therefore noisy people are bald."

Four Terms.—Every syllogism must have three and only three propositions.

The syllogism:

Pericles rules Athens

Pericles' wife rules Pericles

Therefore Pericles' wife rules Athens

may appear to have only three terms, but really has four—

1. Pericles

2. Pericles' wife

3. Athens

4. What rules Athens

B. VERBAL FALLACIES.—Besides the formal syllogistic fallacies logicians have classified fallacies into verbal and material. The distinction is easy to recognize: the material fallacies rest upon a misconception of the natures of things, the verbal fallacies show a confusion of speech. Since the verbal fallacies have largely to do with the construction of propositions and deductive thinking, we will describe them here.

Accent.—Fallacy of accent arises from emphasis being placed on the wrong words of a sentence. Jeremy Bentham so feared falling into this fallacy that he employed to read to him a man with a particularly monotonous voice. To quote an author by unfairly tearing a passage from its context or in quoting to italicize words unitalicized in the original are fallacies of accent.

Amphibology means ambiguous grammatical construction of a sentence. The sphinx couched its prophecies in the form of amphibology—i.e., "If Croesus should wage war against the Persians he would destroy a mighty empire."

Composition and Division.—Composition is the fallacy of arguing from each to all. Consider any group of people, stood in line from the tallest down to the shortest. It is true that any man in the group would be moved nearer to the head of the line if five inches were added to his height. We have here a proposition which holds for each. But suppose we apply it to all. Suppose we say, "If five inches were added to the height of every one of these people, they would all be moved nearer the head of the line." This does not follow, each would be higher absolutely than before, but not relatively.

A beautiful example of the fallacy of composition appeared in July, 1944, in Ripley's *Believe It or Not* column. He stated that the gold in sea water if distributed per capita among the human race would make everybody a millionaire. Of course, everybody would be just as he was. We do not believe that one, Mr. Ripley.

Division is the converse of composition—that because something holds for all it will hold for one.

Example: "We can always trust the majority to do right: X is a member of the majority and we can always trust him to do what is right."

Dicto simpliciter is a fallacy in the "If P" part of the inference, "If P then Q," when an argument depends for its point on the acceptance of an unqualified generalization.

Example: "It is my duty to do unto others as I would have them do unto me. If I were puzzled by a question in an examination, I would like my neighbor to help me out. So it is my duty to help this man beside me."

Equivocation, using a word in two or more senses—i.e., "Whoever obeys laws submits to a governing will: Nature obeys laws: Therefore Nature submits to a governing will."

Contradictory Premise.—"What would happen if an immovable object met an irresistible force?" The catch here is that the premise conceals a weakness which, when indicated, deprives it of any point. In fact, there are two premises, an immovable object and an irresistible force, and they are contradictory.

Homonymy.—Schopenhauer, in *The Art of Controversy*, defines the fallacy of homonymy as the misuse of words having the same sound, but different meanings, i.e., "dumb" mean either physically incapable of speech, or stupid.

Paronymous Terms.—Figure of speech—i.e., "The only proof that a thing is visible is that people see it. The only proof that a sound is audible is that

people hear it. The only proof that a thing is likable is that people like it. The only proof that a thing is desirable is that people desire it."—J. S. Mill, *Utilitarianism*.

Irrelevant Thesis.—This fallacy is applicable to therapeutics but, so far as I can try to recall an instance, not to diagnosis.

Example: There is a principle in politics known as *laissez faire* which states that if you let things alone, a minimum of trouble will result. Suppose this argument is advanced: *Laissez faire* is an unsound principle of social philosophy. Need anyone be reminded that we are sadly mistaken if we think we shall, by letting things look after themselves, attain to a social utopia? The argument is unsound because the attainment of a social utopia is an irrelevant thesis. No one was asking for the attainment of a social utopia.

Ignoratio elenchi is ignoring the point at issue. It is a form of irrelevant evidence. It results in substituting for the conclusion to be proved some other proposition more or less nearly related to it. Many of the arguments brought against scientific theories belong to this class. Mill (*System of Logic*, Book V, chap. VII) cites the arguments which were brought against the Malthusian doctrine of population:

"Malthus has been supposed to be refuted if it could be shown that in some countries or ages population has been nearly stationary, as if he had asserted that population always increases in a given ratio, or had not expressly declared that it increases only in so far as it is not restrained by prudence, or kept down by disease. Or, perhaps, a collection of facts is produced to prove that in some one country with a dense population the people are better off than they are in another country with a thin one, or that the people have become better off and more numerous at the same time; as if the assertion were that a dense population could not be well off."

The *argumentum ad populum* and the *argumentum ad hominem* are examples of *ignoratio elenchi*. The funeral oration of Mark Antony in Shakespeare's *Julius Caesar* is a beautiful example of the *argumentum ad populum*. The question was, "Was Caesar guilty of ambition and did he want to be made king of Rome?" Mark Antony answered that Caesar's will showed he gave all his money to the people, and so on.

Another subdivision of this fallacy is the *argumentum ad verecundiam* (venerability), the argument based on authority, the argument to old institutions. It may take one of two forms—that if this was thought in old times by weighty authority it must be right, or it must be wrong. The fallacy is not uncommon in contemporary medical writings. I excerpt verbatim from the published (1931) discussion of a surgical paper the following:

"To talk of the cure of peritonitis and other complications of appendicitis is like bringing out a ghost of yesteryear, or more like an echoing voice of the past."

The point under discussion was the proper treatment of appendicitis. That what the speaker recommended was like an echoing voice of the past was probably true. But it had nothing to do with the subject, which was, "Is the treatment I advocate a good one?"

Analogy

Analogy is a form of inference which falls between deduction and induction. Deduction moves from a general proposition to a conclusion of a general nature. Analogy suggests an inference by moving from one particular case to another (similar) particular case. The question raised by analogy is whether some particular procedure would be good or some particular statement is true. The validity of the argument rests on adducing another particular procedure which is known to be good or another particular statement which is known to be true, and asserting that the first is more or less exactly similar to the second.

The procedure may be graphically represented thus:

S 1 is P

S 2 is similar to S 1.

Therefore S 2 is P.

Analogy has been a very useful method in science. Darwin's generalization on the origin of species was probably suggested to him by analogy.

Darwin started a notebook in 1837 to record all facts in Nature in any way connected with the variation of species under domestication and in Nature. "I soon found," he wrote, "that selection was the keystone of man's success in making useful races of plants and animals."

On the subject of population he found that, according to Malthus, human beings increase in a geometrical ratio and food increases in an arithmetical ratio. This Darwin applied to all living Nature and saw that the struggle for existence brought about a natural selection to the deliberate selection of breeders and horticulturists, which produced new species in wild Nature.

It is not difficult to see that this was due to Darwin's wonderful ability to find analogies between apparently unrelated facts.

Analogy is, of course, frequently used in diagnosis. The reasoning runs: Patient A has symptoms and signs similar to those of Patient B. We know that Patient B had Disease I. Therefore Patient A has Disease I.

Analogy is, however, of all forms of reasoning the one most open to fallacies. *Post hoc, ergo propter hoc*, is its real basis and, according to my friend, Dr. Chauncey D. Leake, that is the most frequent and dangerous fallacy in scientific thinking.

Examples of false analogy in the field of general thought (by eminent practitioners) are:

Carlyle's image that in sailing a ship whenever the captain wanted to change the course of his ship he had to call all the crew together and take a vote, can be applied to representative government.

St. Augustine: It is praiseworthy to force people to accept the Gospel for their own good, just as force must be used to prevent a delirious person from throwing himself over a cliff.

Francis Bacon: Nobody can be healthful without exercise. And certainly to a kingdom a just and honorable foreign war is a true exercise. A civil war,

indeed, is like the heat of fever: but a foreign war is like the heat of exercise, and serveth to keep the body in health.

In fundamental medical science I cull from the literature the following examples of analogy and leave to the reader the judgment as to whether they are true or false.

Cell proliferation is the characteristic tissue change after infection. Cell proliferation is the characteristic change in cancer. Therefore cancer is likely to be due to an infection.

The process of immunity and cell reaction in allergy are the same. Immunity is hastened by vaccines. Therefore relief from allergy can be induced by vaccines.

Despite the obscure and conflicting explanations offered for the causation of acne, the primary lesion in this very common skin disease is distinct and constant. This basic lesion is a hyperkeratosis of the pilosebaceous follicle which seems to be identical with the hyperkeratosis of certain skin lesions associated with vitamin A deficiency.

The supreme example of the clinical analogist is the man with one case. He had a case just like that which was cured by heroic doses of iodide of potash—so! Or in diagnosis this patient is exactly similar to Mrs. Jones, who turned out to have a carcinoma of the hepatic flexure of the colon.

Induction

The principles of reasoning which we have outlined above constitute the complete system of Aristotelian, or deductive, logic. They prevailed and served well the thinkers of the ancient and medieval world, because the subjects of intellectual curiosity of those days were metaphysics (which included all they had of natural science), politics, and theology. There was practically no experimental science in the ancient and medieval world, the startling exceptions being Pythagoras, with the experiment which showed the relation between musical notes and numbers, and Archimedes, with the experiment to determine specific gravity; and these are startling because they are unique. As one reviews all that arid waste of speculation they impinge on the consciousness with the effect of an explosion in a quiet room.

The point is the Middle Ages had no need for any logic which reasoned from the particular to the general. But as soon as the scientific Renaissance burst into being—which may be roughly stated as 1543 with the simultaneous publication of Vesalius and Copernicus, followed by such processes as Galileo, Harvey, and Newton introduced—the man of intellect, at least the man of science, felt the need for a standard of reasoning entirely outside of deduction. This was supplied by Francis Bacon in his *Novum Organum*, or Aphorisms Concerning the Interpretation of Nature and the Kingdom of Man. Its date was 1620 (before Harvey, of course, but Bacon must have known of Harvey's experiments). It was, it should be noted, the *New Organon*, the old *Organon* being Aristotle's. Bacon stated very clearly and specifically that the sciences needed a new method of reasoning. "A way must be opened for the human

understanding entirely different from any hitherto known" were his very words. But probably because experimental investigation of Nature had not matured sufficiently in his day, he did not arrive at the final crystallization of inductive logic.

This was done by John Stuart Mill in his *System of Logic* published in 1843. Mill laid down the Canons of Induction, which the diagnostician uses every time he arrives at a conclusion.

Induction is the method of reasoning from the particular to the general, from data to conclusion. The scientist accumulates, by observation or experiment, the data. The problem is to determine what they prove or what they mean. In determining the validity of such conclusions the scientist is guided, according to Mill, by five Canons of thought.

They are the Canon of Joint Agreement, the Canon of Difference, the Canon of Concomitant Variation, the Canon of Joint Method of Agreement and Difference, and the Canon of Residues.

1. **The Canon of Joint Agreement.**—"If two or more instances of phenomena under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon."

The purpose of this Canon, or method, is to help us determine what particular facts in our experience are connected as causes and effects. Let P1, P2, P3 represent different instances of a phenomenon (it may be as well as anything the symptom of a disease). And suppose we are able to analyze:

The antecedents of P1, into a, b, c, d
The antecedents of P2 into g, f, e, m
The antecedents of P3 into k, l, n, e

Now it is clear that e is the sole circumstance in which the antecedents of all these instances of P agree. We are justified in concluding that e is probably the cause of the phenomenon under investigation. Jevon's formula is "the sole invariable antecedent of a phenomenon is probably its cause."

Example: "It is remarkably strange that while the chloroform has not changed, while the constitution of the patients has not changed, where the use of the inhaler is the rule there are frequent deaths from chloroform: whilst in Scotland and Ireland where the use of the inhaler is the exception deaths are proportionately rare—" Creighton.

2. **The Canon of Difference.**—"If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance in common save one, that one occurring only in the former: the circumstance in which alone the two instances differ is the effect, or the cause, or an indispensable part of the cause, of the phenomenon."

Or, as stated by Mellone (*An Introductory Textbook of Logic*), "When the addition of an agent is followed by the appearance, or its subtraction, by the disappearance of a certain event, other circumstances remaining the same, that agent is the cause of the event."

Or stated in still another way—"That which is present in a case when a phenomenon occurs, and absent in another case when that phenomenon does not occur, all other circumstances remaining the same in the two cases, is causally connected with that phenomenon."

To represent the situation graphically:

PHK results from ALG
HK results from LG
P is causally connected with A.

3. Canon of the Joint Method of Agreement and Difference.—"If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance, the circumstance in which alone the two sets of instances differ is the effect or the cause or an indispensable part of the cause of the phenomena."

Graphic illustration of the canon:

P occurs in the following instances:
Instance I—when A B C D E operate
Instance II—when F C A G H operate
Instance III—when D M B C E operate
Instance IV—when K N C G A operate

The method of agreement leads to the conclusion that C is causally connected with P.

P does not occur in:
Instance I—when B K N G A are present
Instance II—when D E B M F are present
Instance III—when K L S G B are present
Instance IV—when X E N A F are present

The absence of C and the absence of P indicate that they are causally connected. This, taken in conjunction with the presence of P and the presence of C in the first set of instances, makes the causal connection very much more probable than either alone.

Whether consciously or subconsciously every physician, in making a diagnosis, observes the Canons of Agreement, Difference, and Joint Agreement and Difference. I say this because I believe that in mental processes of making a diagnosis, whether consciously or unconsciously, the physician first summarizes the findings of the patient's examination, and then he lists in his mind all the diseases which could possibly cause them, and he constructs a mental image of all the symptoms and signs of those diseases, and the image which corresponds to his patient's findings is the diagnosis.

All the tables of differential diagnosis which are sprinkled through medical textbooks and journals are simply attempts to formulate a guide by which the Canon of Agreement, the Canon of Difference, and the Canon of Joint Agreement and Difference can be applied.

In his two volumes on *Differential Diagnosis*, published at a time that now seems long ago (1911 and 1918), Dr. Richard C. Cabot presented a series of case histories with a "discussion" of each, exercises which he thought would be instructive to medical students and physicians. In my experience they were, and still are, valuable. Let me extract a few of the discussions which follow the record of the history and physical findings and ask you to note how closely these observe the method of the Canon of Agreement, the Canon of Difference, and the Canon of Joint Agreement and Difference.

I. PRESENTING SYMPTOM: ABDOMINAL TUMOR RIGHT LOWER QUADRANT.—

Summary of Symptoms and Signs.—Male, aged 38 years. Tenderness and soreness in right lower abdomen for ten months. For six months a palpable lump has been present. No other physical signs. Patient the picture of health.

Discussion.—With a lump in the region of the cecum one has always to consider especially cancer of the cecum, appendix abscess, and pericecal tuberculosis. The latter disease does not often begin in a man of this age. It would also probably be associated with some fever and the palpable mass would be less sharply outlined and circumscribed.

An appendix abscess would hardly persist so long unchanged. Ten months without more variation in symptoms or signs is a very long period for an appendix abscess.

Against cancer of the bowel we have nothing except the fact that the patient is the picture of health. It seems extraordinary that a cancer which has existed as long as we have reason to believe it has in this patient should have affected the patient's general condition to so trifling an extent. This consideration led me to think that a pericecal exudate, dependent upon an inflamed appendix, was the most probable diagnosis.

Outcome.—On the twenty-eighth of July the abdomen was opened and the cecum found to be involved in a hard mass of tissue, apparently not inflammatory, but more like malignant disease. A bit of the tumor was excised, and when examined in frozen section seemed to be not inflammatory or tuberculous, but probably new growth.

II. PRESENTING SYMPTOM: DIARRHEA.—

Summary of Symptoms and Signs.—Female, aged 18. Complained of pain in lower left side of abdomen for two years. Physical examination negative. Second admission to hospital a year later with same pain, diarrhea, edema of ankles, and weight loss. Physical examination negative except possibly some fluid in the abdomen.

Discussion.—We utterly failed to understand the case during the patient's first stay in the hospital. She remained only a week because we could find nothing wrong on physical examination. The long-standing pain in the left iliac region might have suggested in an older person a diagnosis of cancer of the sigmoid or diverticulitis, but the patient's age (18) makes these practically impossible.

Pelvic disease, such as pus-tube, was considered, but apparently ruled out as a result of the thorough examination under ether. Our diagnosis, when she left the hospital April first, was *gastric neurosis*.

When she returned, six months later, the steady loss of weight and strength, the diarrhea, swollen ankles, emaciation, and fever made it clear that we were dealing with a chronic infectious disease. The most definite localizing sign was the character of the stools, which showed conclusive evidence of intestinal ulceration, namely, blood and pus.

Ordinarily, I think, not enough attention is paid to the importance of pus in the stools. Many hospital records never mention it, yet it is present in a great majority of cases of intestinal ulceration and is more distinctive of that condition than blood. Given the evidence of ulceration in the bowel, one has still to inquire the *cause* of this ulceration. In temperate climates one may rule out amoebic dysentery unless the patient has previously resided in a tropical or subtropical climate. Aside from this variety of ulcerative enteritis, we know nothing of the causes of such a condition, except that a small proportion of them are due to tuberculosis. The great majority reveal no cause, either during life or after death. It sometimes appears that diseases which lower the patient's power of resistance make him liable to infection in the intestine, as well as elsewhere. Perhaps the bacteria ordinarily present in or upon the intestinal wall may attack the tissues when long-standing diseases, such as cirrhosis, nephritis, diabetes, or arteriosclerosis, have weakened the system. However this may be, it is certainly true that, in the great majority of cases, ulcerative enteritis, arising in temperate climates, shows no known etiologic agent.

This is of some importance because the diagnosis of tuberculous enteritis is so often made wrongly in cases of long standing diarrhea. In my opinion this diagnosis should never be made unless there is abundant evidence of tuberculosis in the lungs or peritoneum, to one of which intestinal tuberculosis is usually secondary. The demonstration of ascites on the eighteenth made it natural to assume that the accompanying enteritis was of tuberculous origin.

Outcome.—On the twenty-sixth I made the diagnosis of tuberculous peritonitis with tuberculous enteritis. On the twenty-ninth the patient died. Autopsy showed tuberculous ulceration of the small intestine and one tuberculous ulcer in the large intestine; also tuberculosis of the mesenteric and peritoneal lymph glands; amyloid degeneration of the spleen and kidneys; no tuberculosis of the peritoneum; no ascites.

Although my diagnosis was half-right in this case, even this degree of success was largely accidental, for my diagnosis rested chiefly on the supposed presence of free fluid in the peritoneal cavity. This is a mistake not infrequently made in patients who have diarrhea, as the intestines with their fluid contents can probably shift from side to side in such a way as to stimulate the movement of free fluid.

III. PRESENTING SYMPTOM: FEVER.—

Summary of Symptoms and Signs.—Male, aged 27. Onset with a cold, cough, and weakness two weeks ago. Temperature above 101° F. every day. Physical examination negative except for scattered râles in both lungs. Widal negative. Leucocytes 13,000.

Discussion.—It seems natural to associate the fever and the rather indefinite pulmonary signs as cause and effect, but it is hard to see how these signs can be considered sufficient to represent a pneumonia, an acute pulmonary tuberculosis, or an empyema, which are about the only lung diseases one would think of in this connection. Tuberculosis seems perhaps the most probable of the three, but we have no positive evidence of this in the sputa or elsewhere.

Let us attack the problem from a different point of view. As I have elsewhere shown, there are but three *obscure* continued fevers in New England which last over two weeks—typhoid, tuberculosis, and pyogenic infections (sepsis). The other fevers, such as those due to meningitis, to acute articular rheumatism, to leucemia, pernicious anemia, syphilis, or malignant disease, are rarely "*obscure*"—that is, they show, as a rule, some obvious lesions as their cause. Returning then to our case with this clue, it seems that we may exclude

typhoid because of the continued leucocytosis, the continued absence of the Widal reaction, the excellent appetite, the absence of splenic enlargement, and the time of year.

Sepsis is not so easily excluded, but the great majority of cases show either (a) a definite localized focus or source of infection, or (b) in the absence of such a focus, a much more serious clinical picture. This patient does not seem much sick, especially when we compare his condition with that of patients with generalized pyogenic infection without demonstrable source.

Can pulmonary tuberculosis which shows its presence by signs as slight and as few as in the present case be yet responsible for such marked and continued pyrexia? Experience shows that it can. Nothing is more remarkable, as one studies a large series of cases of pulmonary tuberculosis, than the discrepancies between the amount of lung involved and the amount of constitutional disturbances, such as fever, prostration, emaciation, indigestion. Some patients, in whose lungs two or three lobes are obviously infiltrated, feel scarcely sick at all, and keep about their work for many months. Others, in whom we can scarcely discover enough physical signs to assure the diagnosis, are utterly prostrated, drenched with sweats, constantly febrile, unable to digest and rapidly emaciate. Presumably these differences are due in part to the variations in individual resistance, in part to the nature of the secondary infection ingrafted upon the original tuberculosis.

Outcome.—After many examinations tubercle bacilli were found in the sputum.

IV. PRESENTING SYMPTOM: VOMITING.—

Summary of Symptoms and Signs.—Female, aged 27. Occasional indigestion for two or three years. Nausea and vomiting every day for eight weeks. Catamenia absent for two and a half months. Dull pain in chest began five days ago with dyspnoea, cough and sputum. Dullness and absence of breath sounds over right chest. Seventy-four ounces of yellow, turbid fluid withdrawn from chest. Vomiting continued after tap.

Discussion.—The pleurisy which was so easily demonstrable in this patient's chest seemed at first a sufficient reason for her vomiting. We were, therefore, surprised that the vomiting continued after the effusion had been tapped. Neither the temperature chart nor any of the other signs in the case seemed to indicate that the tuberculosis, presumably in the background of this pleural effusion, was the cause of the vomiting.

There appeared to be no reason to suspect organic disease of the stomach, brain, heart or kidney. There was no constipation, or toxemia apparent. We might have been tempted to settle down on the unsatisfactory diagnosis of "gastric neurosis." One fact, however, still remained unexplained—namely, the amenorrhœa. This was not to be accounted for by anemia or by any obvious psychic cause. Clearly it was our duty to investigate the possibility of pregnancy.

Outcome.—Tuberculous salpingitis was suspected. Vaginal examination showed a mass in the pelvis distinguishable from the uterus, softer and more fluctuant on the right than on the left. A great number of remedies for vomiting were tried, among them sodium bicarbonate, 1 dram in half a glass of hot water, sipped, Hoffman's anodyne, 1 dram in hot water, ginger ale with sodium bicarbonate in sips, mustard leaf to the epigastrium, bismuth and betanaphthol, cerium oxalate, 2 grains every two hours, and various diets. Finally all food by mouth omitted. As the patient continued to vomit and retch at times, though the nutrient enemata were well retained and did not cause discomfort, it seemed best again to explore the pelvis, with a view to freeing adhesions and perhaps stopping the vomiting in this way. Accordingly, on the twenty-

first the abdomen was opened and showed nothing but a large, presumably pregnant uterus, with normal tubes and ovaries. Within five days after this exploratory operation vomiting ceased altogether.

Diagnosis. Vomiting of pregnancy.

V. PRESENTING SYMPTOM: JAUNDICE.—

Summary of Symptoms and Signs.—Female, aged 38. Attacks of headache and vomiting for nine years. For two years loss of weight and strength. Jaundice for three months, varying in intensity. Physical examination negative.

Discussion.—A gradual decline in weight and strength during a period of two years, leading to a jaundice of three months' duration and of variable degree, and accompanied by occasional attacks of vomiting, is rather an unusual clinical picture in a woman of thirty-eight. Why should the loss of weight have preceded the jaundice unless some form of malignant disease is present? Yet if any such disease were present it should, by this time, show more obvious evidence of itself. Without ascites, marked gastric symptoms, or palpable tumor we certainly cannot make a diagnosis of such terrible significance to the patient. Yet from our minds it is difficult to exclude the thought of cancer.

Cirrhosis or syphilis of the liver would probably show more definite signs of their presence after an illness of this length.

Under such conditions, when a jaundice has lasted rather too long to be called "catarrhal," yet has not produced any of the more ominous evidence of cancer, cirrhosis, or syphilis, the outcome usually shows that we are dealing with gallstones. We have to be governed largely by statistical evidence in such cases; direct examination yields very little of value. Indeed, there is no class of disease in which we depend so largely upon the history and upon general statistical experience as we do in diseases of the liver. Physical examination plays here a smaller part than in the diseases of any other organ with which we deal on terms of any confidence.

Outcome.—Gallstones found at operation.

Of course I am fully aware that in actual practice only too often the picture of the symptoms and signs the patient presents does not agree exactly or even very remotely with any ideal picture of disease, even allowing for differences, and joint differences, and agreements. In that case the diagnostician will either put himself in the position of suspended judgment or, realizing he is up against what in logic is called a dilemma, he will escape by seizing the horns of the dilemma by determining what is the best therapeutic procedure, no matter what the diagnosis is. But I submit that the mental discipline of applying the canons of agreement, difference, and joint difference and agreement will help him decide he is in that position.

4. The Canon of Concomitant Variations.—"Whatever phenomenon varies in any manner, whenever another phenomenon varies in some particular manner, is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation."

The classic illustration of the application of this canon in the realm of science is the connection which has been shown to exist between the aurora borealis, magnetic storms, and the spots on the sun. The magnetic compass is subject at intervals to very slight but curious movements: at the same time there are currents of electricity produced in telegraph wires sufficient to interfere with the transmission of messages. These are called magnetic storms and are observed to occur when a fine display of the northern, or southern, lights is taking place

somewhere on the earth. Observations during many years have shown that these storms come at their worst at the end of every eleven years. Close observation of the sun during thirty or forty years has shown that the number and size of the dark spots which are gigantic storms going over the sun's surface, increase and decrease exactly at the same periods of time as the magnetic storms on the earth's surface. No one can doubt that these strange phenomena are connected, though the mode of the connection is quite unknown.

In the realm of diagnosis one might imagine the following illustration where the application of the canon would solve the question of why a diabetic patient occasionally goes into coma. The patient is an intelligent man who understands the fundamental principles of the physiology of diabetes and the relationship of hyperglycemia, diet, and insulin. All the more surprising therefore that occasionally he lapses into semicoma. It is finally noted that these periods come on after he has visited, as he does at irregular intervals, sometimes a year, sometimes two years, apart, a fishing club to which he belongs, about a thousand miles from his home. It is found that on these trips he relies on a supply of insulin which he keeps at the clubhouse, and which he placed there when he first began to use insulin. Also that on the railroad dining car the steward knows he likes a special dish of fish and when he sees the patient on the way to the fishing resort he asks when he will return and plans to serve the dainty which the patient enjoys, but which, unknown to him, contains a large amount of fat of a special acetone-producing proclivity. The supply of insulin is proved to be inert and the combination of circumstances throws light on the occurrence of the attacks of coma.

5. The Canon of Residues.—"Subduct from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents."

This canon does not have frequent applications to practical diagnosis, so far as I can see. It is used frequently, however, in research in solving problems in pure science, to arrive at a general law, or the explanation of a general phenomenon.

No better explanation could be found than the research which led the Curies to the discovery of radium.

"The particular phenomenon discovered by Becquerel was as follows: uranium compound placed upon a photographic plate covered with black paper produces on that plate an impression analogous to that which light would make. The impression is due to uranium rays that traverse the paper. These same rays can, like x-rays discharge an electroscope, by making the air which surrounds it a conductor.

"Henri Becquerel assured himself that these properties do not depend on a preliminary isolation, and that they persist when the uranium compound is kept in darkness during several months. The next step was to ask whence came this energy, of minute quantity, it is true, but constantly given off by uranium compounds under the form of radiations.

"In order to go beyond the results reached by Becquerel, it was necessary to employ a precise quantitative method. The phenomenon that best lent itself to measurement was the conductivity produced in the air by uranium rays.

This phenomenon, which is called *ionization*, is produced also by x-rays and investigation of it in connection with them had made known its principal characteristics.

"For measuring the very feeble currents that one can make pass through air ionized by uranium rays, I had at my disposition an excellent method developed and applied by Pierre and Jacques Curie. This method consists in counterbalancing on a sensitive electrometer the quantity of electricity carried by the current with that which a piezo-electric quartz can furnish. The installation therefore required a Curie electrometer, a piezo-electric quartz, and a chamber of ionization, which last was formed by a plate condenser whose higher plate was joined to the electrometer, while the lower plate, charged with a known potential, was covered with a thin layer of the substance to be examined.

"My experiments proved that the radiation of uranium compounds can be measured with precision under determined conditions, and that this radiation is an atomic property of the element of uranium. Its intensity is proportional to the quantity of uranium contained in the compound, and depends neither on conditions of chemical combination, nor on external circumstances, such as light or temperature.

"I undertook next to discover if there were other elements possessing the same property, and with this aim I examined all the elements then known, either in their pure state or in compounds. I found that among these bodies, thorium compounds are the only ones which emit rays similar to those of uranium. The radiation of thorium has an intensity of the same order as that of uranium, and is, as in the case of uranium, an atomic property of the element.

"It was necessary at this point to find a new term to define this new property of matter manifested by the elements of uranium and thorium. I proposed the word *radioactivity* which has since become generally adopted; the radioactive elements have been called *radio elements*.

"During the course of my research, I had had occasion to examine not only simple compounds, salts and oxides, but also a great number of minerals. Certain ones proved radioactive; these were those containing uranium and thorium; but their radioactivity seemed abnormal, for it was much greater than the amount I had found in uranium and thorium had led me to expect.

"This abnormality greatly surprised us. When I had assured myself that it was not due to an error in the experiment, it became necessary to find an explanation. I then made the hypothesis that the ores uranium and thorium contain in small quantity a substance much more strongly radioactive than either uranium or thorium. This substance could not be one of the known elements, because these had already been examined; it must, therefore, be a new chemical element.

"I had a passionate desire to verify this hypothesis as rapidly as possible. And Pierre Curie, keenly interested in the question, abandoned his work on crystals (provisionally, he thought) to join me in the search for this unknown substance.

"We chose, for our work, the ore pitchblende, a uranium ore, which in its pure state is about four times more active than oxide of uranium.

"Since the composition of this ore was known through very careful chemical analysis, we could expect to find, at a maximum, 1 per cent of new substance. The result of our experiment proved that there were in reality new radioactive elements in pitchblende, but that their proportion did not reach even a millionth per cent!

"The method we employed is a *new method in chemical research based on radioactivity*. It consists in inducing separation by the ordinary means of

chemical analysis, and of measuring under suitable conditions the radioactivity of all the separate products. By this means one can note the chemical character of the radioactive element sought for, for it will become concentrated in those products which will become more and more radioactive as the separation progresses. We soon recognized that the radioactivity was concentrated principally in two different chemical fractions, and we became able to recognize in pitchblende the presence of at least two new radioactive elements: polonium and radium. We announced the existence of polonium in July, 1898, and of radium in December of the same year.

"In spite of this relatively rapid progress, our work was far from finished. In our opinion there could be no doubt of the existence of these new elements, but to make chemists admit their existence, it was necessary to isolate them. Now, in our most strongly radioactive products (several hundred times more active than uranium), the polonium and radium were present only as traces. The polonium occurred associated with bismuth, extracted from pitchblende, and radium accompanied the barium extracted from the same mineral. We already knew by what methods we might hope to separate polonium from bismuth and radium from barium; but to accomplish such a separation we had to have at our disposition much larger quantities of the primary ore than we had." (From *Pierre Curie* by Marie Curie, The Macmillan Company, 1923.)

Fallacies of Inductive Logic.—

Material fallacies are mistakes in reasoning that depend upon misconceptions of phenomena—of realities rather than, as is the case with logical fallacies, words or rhetoric.

The *fallacy of accident* is sometimes classified as a dicto simpliciter, but it may deal with material things. It is the fallacy of assuming that what would be true in general is true in exceptional circumstances. Man is a rational animal and must be treated as a rational animal, but a drunken man is not rational and cannot be treated as such. A pregnancy follows a general course; hydatidiform moles and ectopics are pregnancies, but they do not follow the course of a regular pregnancy.

An example of fallacy which could be placed under this heading I find in an article on acne (1943). The author states, "Despite the obscure and conflicting explanations for the causation of acne, the primary lesion in this very common disease is distinct and constant. This basic lesion is a hyperkeratosis of the pilo-sebaceous follicle which seems to be identical with the hyperkeratosis of certain skin diseases associated with vitamin A deficiency."

The fallacy here lies in the assumption that unity of pathologic structure means unity of etiology, which certainly is open to doubt.

Converse accident would be to argue that because spirituous liquors were beneficial to a person who is sick they would be beneficial to one who is well.

False cause is the fallacy of attributing a phenomenon to a false cause. Whately's example is: It is frequently assumed that because the men and animals native to countries with an inclement climate, where the conditions of life are severe, are usually robust, that the hardships they are forced to undergo in youth are the cause of this hardiness; whereas their hardiness was the cause of their having survived the hardships.

"A philosopher was shown in a temple votive tablets suspended by such as had escaped the peril of shipwreck, and asked if he would then question the power of the Gods. 'But where are the tablets of those who perished in spite of their vows?' he asked."—Bacon, *Novum Organum*.

All primitive medicine, all magic, is founded on false cause.

The history of medicine is strewn with the shipwrecks of theories dependent on false cause. The osteopath ascribes a pain, a disease syndrome of subluxation of a vertebrae. The homeopath believed the action of his drugs was due to the fact that their action is similar to the effects of the disease—*simul simulibus curantur*. The humoral theory ascribed a set of symptoms to dislocation of the four humors which in health are in balance: blood, phlegm, black bile, and yellow bile.

But more modern examples are at hand. McDevitt, Dove, Dove, and Wright (*Ann. Int. Med.* 20: 1, 1944) report on the vitamin status of a rural population of 600 families in Newfoundland, who, according to the report, live on refined foods, salt meats and fish without an adequate amount of protective food factors. They found in this group 233 persons who had symptoms of vitamin B complex deficiency. The symptoms were: (1) ocular—photophobia, increased lacrimation, snow blindness; (2) digestive—cheilosis, tongue and mouth sore, gastrointestinal distress, epigastric pain and anorexia, flatulence, constipation; (3) cardiac—unusual awareness of heart, shortness of breath; (4) nervous—numbness and tingling, diminished sensation, tenderness along nerves, burning soles, neuritis, leg cramps; (5) constitutional—loss of weight, abnormal fatigue, nervousness.

The first question any real clinician would ask about this is how these symptoms got to be assigned to vitamin deficiency—why not the psychoneuroses? It would be difficult to examine the members of six hundred families anywhere and not find at least two hundred persons who could complain of fatigue, nervousness, lacrimation, flatulence, constipation, and heart awareness.

The history of science is strewn also with the wreckage of theories which depend for their validity on false cause. Of the phlogiston theory of heat Mill wrote (*System of Logic*, Book V, chap. IV):

"The hypothesis accorded tolerably well with superficial appearances: the ascent of flame naturally suggests the escape of a substance; and the visible residuum of ashes, in bulk and weight, generally falls extremely short of the combustible material. The error was non-observation of an important portion of the actual residue; namely, the gaseous products of combustion. When these were at last noticed and brought into account, it appeared to be a universal law that all substances gain instead of lose weight by combustion; and after the usual attempt to accommodate the old theory to the new fact by means of an arbitrary hypothesis (that phlogiston had the quality of positive levity instead of gravity), chemists were conducted to the true explanation, namely, that instead of a substance separated, there was, on the contrary, a substance absorbed."

Irrelevant evidence is sufficiently explained by its name. It is a favorite argument among politicians and social philosophers.

"The gentleman did not argue in this way four years ago."

What of it? The gentlemen may have changed his mind, which might be an improvement. The argument is irrelevant to the question whatever the question is.

If you have a bad brief—abuse the plaintiff's attorney.

But it also appears in medical thinking.

"The tissue response to the invasion of bacteria is a proliferation of body cells. The characteristic of a neoplasm is the proliferation of body cells. Therefore we should find bacteria as the cause of neoplasm." There are several fallacies in this, but one is certainly that the reaction of bodily cells to bacterial infection is irrelevant to the cause of neoplasms.

Neglected aspect seems superficially the same but is quite different from irrelevant evidence. In an argument from irrelevant evidence, you may say that all the evidence you bring is quite true, but it has nothing to do with the case. You say—"Evolution cannot be true. The great Agassiz did not believe in it. No one ever saw anything evolve. It is not compatible with revealed religion." I say—All these statements are true, but what of it? They have nothing to do with the case.

Neglected aspect is a form of reasoning in which every argument advanced to support the thesis is true but the reasoner neglects all the arguments that do not support the thesis.

Example: "In this town prohibition threw 5,000 people out of work: deprived 2,000 landlords of their tenants; deprived the town of \$300,000.00 in excise and property taxes; depreciated the rental value of \$5,000,000.00 worth of property; drove several millions of dollars of capital elsewhere which would have been invested here. Could the case for amendment be any stronger?" It is not necessary to supply the reader with the neglected aspects.

Medical example: Dr. Marcus A. Krupp (J. A. M. A. 119: 1475, August 29, 1942), reported on the incidence of nutritional and vitamin deficiency in patients entering Stanford University Hospital. He found about a hundred patients who were taking inadequate diets. Of these 11.4 per cent showed definite signs of vitamin deficiency. All right, what about the other 88.6 per cent of people who were on an inadequate diet, but showed no vitamin deficiency? Why does an inadequate diet work one way eleven times and another way 88 times? When such questions arise in the mind of the reader, he wonders whether the survey amounts to anything—whether the patients really had inadequate diets and whether the symptoms noted were really indicative of vitamin deficiency.

Hypothesis contrary to fact. Any chain of reasoning which depends on what would happen or what has happened, *if something were the case which is not the case*, is false because it employs hypothesis contrary to fact. Or one may reason on the basis of an hypothesis about which nobody knows any data. For instance, from Karl Pearson:

"Suppose a man were to travel away from the earth with a velocity greater than that of light. Clearly all natural processes and all history would be reversed for him. Men would enter life by death, would grow younger, and

would leave it finally by birth. Complex types of life would grow simpler, evolution would be reversed, and the earth growing hotter and hotter would at last become nebulous."

There is a fallacy which did not appear in Aristotle, Mill, or any of the classic logicians. It was pointed out in Castell's *College Logic*. He called it *poisoning the wells*. Cardinal Newman wrote his "Apologia pro Vita Mea" in reply to Charles Kingsley's statement that truth did not possess the highest value for a Roman Catholic priest: That some things were prized above truth. Newman protested that such a statement made it impossible for an opponent to state his case. How could Newman prove to Kingsley that truth did not have the highest value for him when Kingsley's premise was that being a Catholic priest, it didn't; Kingsley's argument hamstrung his opponent. Newman called this "poisoning the wells."

Modern medicine is saturated with a doctrine which in the same way hamstring any attempt to refute it by reason or argumentation—the doctrine of psychoanalysis. The psychoanalysts say that our actions and beliefs are dependent upon events that we may have thrust into our subconscious and forgotten. And if an opponent argues that such is not the case, the psychoanalysts say he says that because he has forgotten and thrust into the subconscious the experiences that would prove it to him. As Professor Heidebreder says in *Seven Psychologies*, "At the threshold of any attempt to evaluate the doctrine of psychoanalysis is a curious and significant difficulty. If the theory be true then the prosaic business of considering pros and cons may itself be an expression of unconscious motives, and any objections that arise to a critic's attention may be unconscious defenses against unwelcome revelations. In that case the objections themselves constitute evidence of the system's essential rightness: for their occurrence means that the critic finds the import of psychoanalysis objectional and is protecting himself in the manner predicted in the theory. To be more specific, if the critic rejects the theory in its entirety he may be acting in self-defense. If he is friendly toward the theory as a whole, reserving his objections for one or two points, he may be employing simply a subtle defense, attempting to protect his most sensitive wounds" [i.e., suppose he objects to the mother fixation—Oedipus—complex part of the doctrine] "by conceding points that do not greatly concern him. Even if he gives good reasons for the stand he takes, he can never be sure he is not rationalizing: because his motives may be deep in his unconscious."

Petitio principii is begging the question. An argument must not move in a circle. Aristotle's example was: "Good is that of which a good man approves and a good man is one who approves of that which is good."

Another: "Whatever is said by Joseph Smith is true because the Book of Mormon states that Joseph Smith is a prophet: and what the Book of Mormon states is true on the grounds that Smith received it from God: and that Smith received it from God on the grounds that he (Smith) says so."

This woman's symptoms are due to enlarged thyroid because she has enlarged thyroid and she has these symptoms.

Non-sequitur is a fallacy in inference. It is the *post-hoc, ergo propter hoc* principle—after which therefore because of which. We have analyzed under evaluation of evidence the necessity of examining and fortifying the strength of the agent so there can be no doubt that it is the cause of the effect. Such pains every scientific mind will take to avoid a non-sequitur.

Probanda and the Nature of Proof

Mill's Canon satisfied the intellectual needs of logicians in science for nearly half a century. But any scientist, any physician or diagnostician, must be conscious of a feeling of inadequacy in using them. Are these, then, the only processes of reasoning I go through in thinking about a scientific problem? That is the question he inevitably asks himself. He will almost certainly formulate his skepticism by realizing that there are two forms, or kinds, or methods of thinking which he uses every day and which are not accounted for by Aristotle's definitions and deductions, or by the canons of inductive reasoning as laid down by Mill.

One is the use of the imagination. The scientist has always employed hypothesis and theorem to furnish a scaffolding for his experiments and observations.

The other is the calculation of probability. The syllogism of Aristotle and the canons of Mill alike aim at certainty. They seem to imply that every problem is capable of being solved in a definitely positive or a definitely negative manner. The diagnostician, of all people, realizes from his earliest experiences that no such goal is attained or attainable in a large proportion of his problems. Is it possible to formulate some rules of probable inference?

These questions were by no means ignored by professional logicians. The morning star of the "new logic" was probably Johann Friederich Herbart, whose *Hauptpunkte der Logik* was published in 1808, and *Psychologie als Wissenschaft (Psychology as Knowledge)* in 1824-1825. His influence was considerable on F. H. Bradley, who, in a work *The Principles of Logic*, the first edition of which was published in 1883, opened the minds of English-speaking readers to the inadequacies of Aristotle, Mill, etc. Karl Pearson's *Grammar of Science* (1892) and F. C. S. Schiller's *Formal Logic* (1912) are brilliant and vocative expressions of the same line of thought. In the field of probability the modern scientific logician recognizes his indebtedness to Laplace (*Theorie analytique des probabilités*, 1812), to C. S. Pierce (*A Theory of Probable Inference*, 1883), to H. Poincaré (*Calcul des probabilités*, 1893-1894), and to J. M. Keynes (*A Treatise on Probability*, 1921).

The concern of the new logic of the twentieth century may be said in general to have been with the nature of proof. Aristotle and, to a less extent, Mill, would seem, as far as we can interpret them, to assume that, by the application of the proper rules, it is possible for us to arrive at certainty. The new logic is at pains to analyze the elements that enter into proof and to conclude that there are very few things in the world of which we can be absolutely certain.

It will, I hope, come as a surprise to my readers that each of us goes through life confidently planning on the certain occurrences, which confidences rest on pure assumptions. Professor Broad goes so far as to say it is a "public scandal." Let me take you through a typical day. You get up in the morning, dress and go into the kitchen, put on the coffee with certain expectancy that the water will boil at a temperature of 212° F. This is not certain to happen: it is an assumption, resting on a generalization (*vide infra*). You go to the hospital and you find a patient whom you have never seen, whom you assume is who he tells you he is, named Gideon Heliogubalus, who has a broken bone, which you assume he received under such-and-such circumstances, and which you proceed to reduce according to certain rules in the expectation that it will heal, all of which constitute not certainties at all but reasonable assumptions based on hypothesis (*vide infra*).

After his assurances you confidently expect that he will compensate you adequately, and with this compensation you will pay the butcher, which is not a certainty but an evaluation (*vide infra*). After your day is over, as a preliminary to retiring, provided your early training has been gentle, you address a few thanks and hopes to a deity for whose existence I am very firm though reluctant in telling you there is no proof whatever, except as it rests on a pure theorem (*vide infra*).

You, however, have to act as if all these assumptions were certainties and so for practical purposes they turn out to be. Your life is successful only on the basis of the reliability of these assumptions. The diagnostician is in the same position. He perhaps can never, on the basis of strict metaphysical logic, prove his diagnosis, until the matter comes to autopsy and not always then. Certainly by then it is too late for therapeutics, and in this life diagnosis is valuable merely as a preliminary to therapeutics. So he must restrain his intellectual skepticisms and proceed practically on the assumption that his diagnosis, subject to the entrance into the problem of new data, is quite valid and furnishes the basis for his treatment.

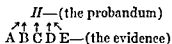
It may be argued that the practical diagnostician has no need to acquaint himself with these metaphysical and somewhat nebulous niceties of the newer logic; that the older solid methods of deductive and inductive logic quite suffice him. To a considerable extent I agree with that judgment. Still, one may have reservations. A free man will demand to know all the grounds for his convictions or hesitations. Besides in the purely practical realm, as we all know only too well, many a case confronts us in which we are certain of the diagnosis. Practical reasoning then comes down to the balance of probabilities. And this is pre-eminently the realm of the new logic. I will, therefore, review the subject of probanda.

A probandum is a proposition to be proved. There are different kinds of probanda. They fall into a few categories, each of which is best approached by one of the methods to determine the nature of proof—hypothesis, generalization, theorem, evaluation.

An **Hypothesis** is an informed theory of causation. In less stilted language it is a shrewd guess. It is a theory by the very nature of the term, not a con-

viction of certainty. But it has not been arrived at in the scientific mind without some observed and proved facts to go on—that is why I say informed. The three most famous hypotheses of natural science are the nebular hypothesis, the doctrine of evolution, and the atomic theory. None of them probably can ever be definitely proved by human observation, yet each is supported by a set of facts which lead toward the final formulation. They are very useful to scientists because in practice they work. They explain things. Probably for that reason more than for any other scientists regard them with what amounts to conviction. Yet in our own day and experience, in each new facts have been brought forward which have made us revise, to some extent, our conceptions of exactly how they operate. That scientists have been able rapidly and easily to accept these new conceptions shows that they do not attain to the dignity of laws.

An hypothesis is supported by a series of facts or phenomena, more or less related but entirely different, which converge to the formulation of the hypothesis. It may be represented diagrammatically thus:



We may illustrate an hypothesis by referring to the Ptolemaic and Copernican theories of the universe. For over a thousand years men lived by the Ptolemaic theory that the earth was the center of the universe. They told time by it, they calculated the seasons, they regulated their lives by it. For the last four hundred years they have succeeded equally with the Copernican theory that the sun is the center of the solar system. In the great scientific Museum at Munich you can, or at least you once could, go into a planetarium showing the skies and the movements of the sun, moon, and planets constructed on the Ptolemaic model. And then you could go into a planetarium showing the same things on the Copernican model. We accept the Copernican system only because it explains a few more phenomena than the Ptolemaic system.

There are four major phenomena which are explained as well by the Ptolemaic as by the Copernican systems. The succession of day and night, indeed, to our untrained senses is better explained by the idea that the sun revolves around the earth, than that the earth revolves on its axis. The succession of the seasons can be explained by assuming that the sun revolves around the earth in a sort of spiral so as to be a little farther north on each succeeding day from December to June, and a little farther south each succeeding day from June to December. It is in fact as easy to believe as that the earth tips on its axis. Eclipses and changes of the moon are also understandable on the Ptolemaic theory.

There are, however, seven phenomena—tides, the motions of the planets with respect to the fixed stars, the fact that a weight dropped from a great height falls a little to the east of vertical, the fact that a pendulum changes its plane of vibration and a gyroscope its axis of rotation, that the equatorial diameter of the earth is greater than the polar diameter, and the location of

certain constellations at different periods of the year—that can be explained only on the Copernican theory. For such reasons astronomers accepted the Copernican over the Ptolemaic hypothesis.

An hypothesis, therefore, gain in credibility, in certainty, as it explains more phenomena, or explains them better.

It is obvious that the diagnostician must take into account these principles of hypothetical reasoning. It is only the tyro or the ignoramus who regards all his diagnoses as certainties: in most instances, in all complicated instances, the most valid conclusion at which we can arrive is a probable hypothesis.

And this brings us one of the basically fundamental problems in human reasoning—the role of probability.

What the problem involves in effect is—what is the nature of proof?

In order to introduce the subject of probability I shall take an example entirely outside the realm of medicine.

Mr. Weber left home, stating that he was going to a near-by town on business. The day on which he was to have returned, the train was wrecked. Neither Mr. Weber nor his remains were discovered in the wreckage. He did not return home. Mrs. Weber instituted a claim for his insurance on these grounds:

1. A friend saw Mr. Weber in the town to which he said he was going and from which the train which was wrecked left.
2. The ticket agent saw Mr. Weber board the train in question.
3. A banker friend who had been on the train, but got off before the wreck occurred, saw Mr. Weber on the train.
4. A bunch of keys found in the wreck was recognized as Mr. Weber's by his wife.
5. One of the keys fitted a lock in their house; another fitted the front door; a third fitted their clothes closet.
6. A locksmith swore he had made one of those keys for Mr. Weber.

The insurance company was about to settle the claim when Mr. Weber turned up.

Let us analyze this situation because it is fundamentally important for the points we are trying to make. Its analogy to many diagnostic problems is self-evident.

First, let us keep clearly in mind that the evidence is attempting to prove an hypothesis. And also keep clearly in mind what the hypothesis is—that Mr. Weber perished in the wreck. The hypothesis and the six points of evidence can be diagrammed, as for any hypothesis, as on page 38. In argument it too often happens that what we are trying to prove is not stated clearly or kept clearly in mind. It is the duty of the logician to hold every-one to the point.

Second, after the case was solved by the return of Mr. Weber and the hypothesis was shown to be untenable, the pieces of evidence were just as true, just as much facts, as when they were used as evidence to converge on the hypothesis. They were simply seen to have another explanation. I think

everyone will agree that this is an extremely important conception for the diagnostician to keep in mind when he is dealing with the data of a complicated or obscure case.

Third, note that every piece of evidence that was brought forward strengthened the others. The fact that Mr. Weber was recognized in the town from which the train departed was of some value. That the ticket taker recognized him when he got on the train was more, but can be easily explained away on the grounds of mistaken identity. But that the banker recognized him on the train is not only stronger evidence than the other two, but strengthens them. The finding of the keys and their identification would seem final to us, had we not had the cultural advantage of studying the logic of hypothesis.

Now the question is—when does probability get so strong that it amounts to certainty? Are there any standards by which this can be decided? It would seem a priori that it would be subject to mathematical calculation.

Let us say, for purposes of argument, that the police are looking for a white man who is identified as having a birthmark on his left cheek, a scar on the back of his right hand, and walks with a limp. Let us assume that there are 33,000,000 white adult males in the United States and that 1,000,000 of them have a birthmark on the left cheek. When the police pick up such a person, therefore, the probabilities are 33 to 1 that they have the man they want. But if, on further examination, it is found that the man has also a scar on the back of his right hand the chances are not now doubled, but, assuming that there are a thousand adult white males who have both a birthmark on the left cheek and a scar on the back of the right hand, is 1,000 to 33,000. And when it is revealed that the man apprehended also walks with a limp the probability of the police having the right man is raised to perhaps 660,000 to 1. Still he might not be the right man; there is always the chance that they have apprehended one of the others.

There are, however, degrees of probability. Can the diagnostician reduce these to a mathematical calculation as to what degree of success his probable inference has attained? Probably not. In the case of the man wanted by the police we are assuming data—the number of such men in the population—which we never have in the case of a diagnostic problem. We may say, in general, that the degree of probability increases with the number and range of the evidences adduced for the hypothesis in question. J. M. Keynes, in his *Treatise on Probability*, however, rejects the "frequency theory" of probability as an intrinsic property of truth. It has, however, respectable backing by C. S. Pierce and Venn (see bibliography). However, I am not sure that a diagnostician's logical technique is improved by an attempt to reduce his probabilities to mathematical terms. In this field logicians have been under the necessity of devising formulas for various problems—the operation of chance, as well as legal, social and the phenomena of Nature on the widest scale—not strictly applicable to diagnosis.

For instance, let us consider the operation of chance, such as in tossing a coin whether it will come up heads or tails. The logician says that the a priori or deductive method of calculating probabilities is possible on the following

conditions: (1) We must know the total number of mutually exclusive alternatives, one or the other of which must happen. (2) The alternatives must be equally likely. (3) We must know how many of the alternatives are favorable to the event concerned. The probability is then expressed by means of a fraction, the denominator of which gives the total number of equally likely alternatives, while the numerator gives the number of alternatives which are favorable to the event in question. The formula is:

$$p=f/t$$

p =probability

f =number of favorable alternatives

t =total number of equally likely alternatives

But I cannot see where this is applicable to a diagnostic problem.

The nearest approach to a formula which would apply to diagnostic problems are these:

To find the alternative occurrence of two events:

- a. When the events are mutually exclusive, add the separate probabilities—

$$Pd(A+B) = PdA + PdB$$

Where P is the probability, d the data, and A and B are the alternative events or occurrences (or diagnoses).

- b. When neither event excludes the other. Add the separate probabilities and from this sum subtract the probability of the combined occurrence of the two events:

$$Pd(A+B) = PdA + PdB - PdAB$$

Obviously the difficulty in the use of these formulae for the diagnostician is the impossibility of assessing d .

We must note a final consideration in the logic of proof: one divergent fact can disprove an hypothesis no matter how many convergent facts tend to prove it. When Mr. Weber returned, that disproof shattered the whole web of evidence-hypothesis relationship set up previously. Science is basically empirical in its results, although its method may be experimental and inductive. A fact remains a fact, not a probandum. The greatest tragedy on earth for Huxley was a beautiful hypothesis killed by an ugly little fact.

We are now in a position to gain some insight as to the nature of what Professor Eaton calls this mystifying probability relation. Probability is not subjective as Hume thought. It has nothing to do with the strength of belief. There are persons who believe very strongly in the existence of the Devil, although the evidence for his existence is slight. The fervency of their belief does not add to the probability of the evidence. The notion of probability is, as Keynes pointed out so clearly, strictly a *relative* one. "No hypothesis has any probability in itself: only in relation to the facts for which it accounts. To say that one hypothesis is inherently more probable than another is meaningless. Probable always means in relation to such and such evidence. Hence, if the evidence changes, the probability changes. As Mr. Keynes observes,

probability is a function of evidence as the area of a circle is a function of its diameter" (Castell). Probability is not comparable to truth, for it is not an intrinsic property of propositions. Probability does not exist *in vacuo*. "Thus," says Keynes, "when in ordinary speech we name some opinion as probable without further qualification, the phrase is generally elliptical. We mean that it is probable when certain considerations, implicitly or explicitly present to our minds at that moment, are taken into account. We use the word for the sake of shortness, just as we speak of a place as being three miles distant, when we mean three miles distant from where we are then situated, or from some starting point to which we tacitly refer. No proposition is in itself either probable or improbable, just as no place can be intrinsically distant; and the probability of the same statement varies with the evidence presented, which is, as it were, its origin of reference. . . . Reflection will show," continues Keynes, "that this account harmonizes with familiar experience. There is nothing novel in the supposition that the probability of a theory turns upon the evidence by which it is supported; and it is common to assert that an opinion was probable on the evidence at first to hand, but on further information was untenable. As our knowledge or our hypothesis changes, our conclusions have new probabilities, not in themselves, but relatively to these new premises."

In order to sum up and apply such insight as we have gained into this probability relation, let us take as illustration an example strictly in the field of diagnosis. The instance is one that could easily be a part of any clinician's everyday experience:

A man, aged 55 years, has been seized quite suddenly in the midst of previous good health with epigastric discomfort, culminating at the end of a few weeks in an episode of collapse with vomiting of blood. On examination, tenderness and an indefinite mass is found in the epigastrium. He has lost considerable weight. He looks cachectic. A lymph node is found on the left side of the neck just above the clavicle (Virchow's node).

The diagnostic hypothesis is carcinoma of the stomach.

The first piece of evidence towards that hypothesis is the man's age and suddenness of onset of the illness. Let us, for the sake of argument, give that the value of 1.

The second piece of evidence is the hematemesis. How far does that raise the value of the probability? Well, there are certainly other possibilities than carcinoma to explain that. Let us say it raises it to 2.

The addition of the mass in the epigastrium would certainly do more than raise the probability one point. It would at least double it, so the probability now has the value of 4.

The loss of weight and evidence of cachexia would certainly raise the probability to 5 points.

Now what about that lymph node? That, by experience, is pretty positive for carcinoma. It should have enough weight to require us to square the 5 points we have and raise the probability to 25.

Now when does probability merge into certainty? The answer is—never.

The exploratory laparotomy in this hypothetical case showed a perforated gastric ulcer. The epigastric mass was omentum attached to the perforated pyloric region, etc. The lymph node was inflammatory.

I turn the consideration of this case over to the speculative reflection of the philosophic diagnostician.

Generalizations.—Now let us get back to that day of yours, which we described in the introductory portion of this subject on page 37, and your certainty that the water for your coffee will boil at 212° F. The only reason for your confidence in that eventuality is that it always has. It is a generalization. The evidence for a generalization differs from that for an hypothesis in that whereas every piece of evidence for an hypothesis is different in nature from the others, the evidences for a generalization are all exactly the same. Your evidence that the water is going to boil is that it boiled yesterday, and the day before, in New York, Chicago, London, etc., etc.

The formula for a generalization then is:

$$\begin{array}{c} G \text{—(the probandum)} \\ \uparrow \uparrow \uparrow \uparrow \\ A \ A \ A \ A \text{—(the evidence)} \end{array}$$

The evidence for a generalization is always a repetition of particular instances.

For instance, the only reason you accept the statement that a person with tuberculosis has a body temperature above normal is that every patient who had a proved tuberculosis has had, some time in the course of his illness, a temperature above normal. To that extent, when found it is a strong piece of evidence in favor of tuberculosis, other things being equal. But there is no inherent reason why tuberculosis should be accompanied by a fever. Oh! I know explanations have been attempted. It is due to increased cell activity—well, then, why doesn't the average patient with sarcoma have elevated temperature? It is due to the absorption of toxins—then why doesn't a patient absorbing digitalis run an increased temperature? I am aware that many researches have been accomplished which partly explain the phenomenon, but they do so only by analogy. The real explanation still escapes us. When we have it, the statement, "Patients with tuberculosis have fever," will be taken out of the plane of a generalization and made into a law.

Such considerations should not be interpreted as implying that generalizations are not valuable. They are, indeed, among the soundest parts of our mental processes. "Probability," as Bishop Butler said, "is the very guide of life." We could not get along in either life or diagnosis without the daily use of the great fundamental generalizations. But it is well to recognize them for what they are, and to see that it is very easy for a thinker to fall into the habit of *hasty generalization*; "Gentlemen prefer blondes" is, of course, the horrible example, but "Fatigue is due to lack of vitamins" is equally horrible. Not that such a habit necessarily results in failure in life; I have known very successful and prosperous practitioners whose whole career has consisted in moving from one hasty generalization to another. In 1900

it was "Strychnine is good for neurasthenia"; in 1910 it was "A redundant caecum results in intestinal stasis and chronic fatigue." In 1915 it was "Vagotonia (or sympathicotonia) is the root of all evil." Later, it was endocrines, and later allergy, and later vitamins. Mind you, I am not saying these are false doctrines, only that they result in hasty generalizations. They are the pitfalls of the faddist.

This leads us to the consideration that in practical life we have to use generalizations of different degrees of probability:

The *primary generalizations* are those to which no exception has ever been noted—all men are mortal, all water freezes at zero centigrade—but which are not necessarily and by their very nature invariable. We can imagine, indeed man always has imagined, immortal men: nor would it take a great fundamental readjustment of the universe to produce some.

One can also imagine H_2O which would not freeze at zero centigrade. The scientific romances of Mr. H. G. Wells are nearly all based upon the imaginative supposition that some familiar generalization has found an exception.

Statistical generalizations, or proportional generalization. The principle of reasoning here is that you have a group of A which are all alike on a general basis, but differ in certain particulars. A certain proportion of A's are B's. "A certain proportion of men are white," is a proportional or statistical generalization.

Obviously the way you arrive, the mental process you go through in arriving at a proportional generalization, is exactly the same as that in arriving at a primary generalization. It is a process of enumeration. But while in life we pick up our primary useful generalizations quite effortlessly, and absorb them early in our careers, it requires deliberate intention to formulate a proportional generalization. In fact, we must have a plan and an objective, if not an answer, in view.

That probably accounts for the bad reputation proportional generalizations have, as embodied in the adage about lies, damn lies, and statistics. But if a statistician tries to twist his proportional generalization to prove a point which he has already provisionally established, he is no statistician.

Statistics constitute a very valuable discipline and represent an extremely useful set of data in all branches of the practice of medicine, diagnosis as well as therapeutics. Of course, the datum with which we, as doctors, are dealing is a unit, an individual—one sick human being—and he may fall outside the realm of any proportional generalization, but when he does, the generalization is very useful. And one of the hopes of practical scientific medicine is that we may gather enough reliable statistical generalizations to cover all cases.

The second part of this book is an attempt to gather as many sets of statistical generalizations about the subject of symptoms as possible.

And in the other chapters I have kept in mind the desirability of doing the same service for physical signs and laboratory data.

Functional generalizations resemble, to a certain extent, proportional generalizations, but on close examination it will be seen that they are genuinely

different. The basic model of the proportional generalization is that a certain proportion of A's are B's. The functional generalization states that A varies with variations in B.

Examples of functional generalizations are:

Atmospheric pressure varies with distance from the earth's surface.

Rate of rent varies with density of population.

Systolic heart murmurs are adjudged functional or organic in respect to the absence, presence, or amount of cardiac hypertrophy.

The pain of a neoplasm varies with its impingement on sensory nerve endings.

Both statistical generalizations and functional generalizations are just as valid, as vigorous, and as inclusive as primary generalizations.

Myxedema affects women more often than men—a statistical generalization.

Gravitational pull varies with mass—a functional generalization.

Water boils at 212° F.—a primary generalization.

All are true and equally true.

Neither statistical nor functional generalizations need be expressed in numerical or mathematical form.

"Myxedema affects women more often than men," is just as true a statement as, "Myxedema affects women four times as often as men."

Proving a Generalization.—It is obvious that while we depend upon the validity of generalizations for nearly every important calculation of our acts in our daily life, there is no other division of our thinking that is so entirely vulnerable. We may feel fairly safe in the conduct of our regular habitual plan of living in depending on the generalization—"Water boils at 212° F. (100° C.)," but we recognize immediately that another generalization and one on which we also depend for daily comfort—"The streetcar stops at that corner every morning at 8:32 just in time to get me to my office," is literally reeking with uncertainty. But, as a matter of fact, so apparently dependable a generalization as that about the water is, if analyzed with extreme critical judgment, almost equally undependable. This is what Professor Broad ventured to call a "public scandal." "Nearly all scientific laws are generalizations and the paradox is that the probability attaching to any generalization, no matter how much evidence has been piled up for it, is vanishingly small. It is indeed a serious matter. What it comes to is that any generalization, such as *All men are mortal* and *All crows are black*, has only an indefinitely small amount of probability." (Castell's *College Logic*.)

The evidence for such statements has been developed at great length in the texts on logic, but I will not attempt to go into it here, because it has only a remote application to the practice of diagnosis. But the philosophical diagnostician should recognize, because he is constantly using generalizations, that this spectre sits at the board.

Theorems.—A theorem is a proposition which states that something is necessarily the case.

Examples of theorems are:

The angles at the base of an isosceles triangle are equal.

The evidence for a theorem is always a set of axioms and from these the theorem is derived by a process of rigid deductions.

Theorems are not used to any extent in the practical everyday working out of diagnostic problems.

Evaluations differ from every other form of probanda in that the essential feature under consideration is not the actual validity of a proposition but its value or comparative usefulness or importance.

Ethics and aesthetics are the fields in which the abstract philosopher most often employs evaluations. "It is better to be honest than to be rich," is an ethical evaluation. "This picture is more beautiful than that one," is aesthetic evaluation.

Since it is my judgment that evaluations are very important for the diagnostician, let us analyze these. In the first place, the statement, "It is better to be honest than to be rich," makes no statement as to whether it is good to be honest or good to be rich. It assumes that both of these are true. But it states that if a choice were to be made, being honest is better. It does not even say that a man cannot be both at the same time. But it states that in that moment when, though both honest and rich, he is honest or, let us say, his honesty is in the ascendency, it is better. What "better" means is obviously a large question.

Now, to continue the analysis, this evaluation is largely emotional. This becomes clear when we leave the ethical and turn to the aesthetic question, "Why is this picture more beautiful than that one *to me*?" Obviously the judgment is largely instinctive: it depends to a certain extent upon the rods and cones in my retina. It is not coldly intellectual. True, it can be to a certain extent educated. If he explained something about Giotto and what he was trying to do, the conditions of life when he worked, a fair-minded person could be made to see that one of his saints is more beautiful than the chromo on a calendar. Or in Mark Twain's phrase, he guessed classical music is not as bad as it sounds.

In our evaluation in diagnosis, however, we have no such judgment to make as those just suggested. We use evaluation after the data about a patient have been accumulated and we are trying to make a summary of the case. The evaluation we make is something like this: "In this particular case the fever is a more important symptom than the rapid pulse."

Professor Castell, in his textbook on logic, which is the only place where I find a clear discussion of evaluations, says that he does not understand what kind of a probandum an evaluation is. He writes: "Is it an hypothesis, probable upon a variety of facts for which it accounts as, e.g., *Mr. Weber perished in the train wreck* was probable upon the facts for which it accounted? If so, what are the convergent facts? If not, is it a generalization, probable upon an argument from instances as, e.g., *All men are mortal* is probable upon the instances which it covers? If so, what are the instances? If not, is it a theorem

deducible from a set of primitives as, e.g., *opposite angles formed by intersecting straight lines are equal* is deducible from the primitives of Euclidian geometry? If so, what are the primitives? If not, if it is like more of these probanda, what then is its peculiar logical status? What is the rationale of these primary evaluations? That is, if reason explores them, what does reason find?" And he concludes that he can formulate no *relationale* for an evaluation. G. E. Moore, in his treatise on ethics, says, bluntly, "No relevant evidence whatever can be adduced by which alone any ethical proposition can be proved or disproved: from no other truth except themselves alone can it be inferred that they are either true or false."

But these scholars are dealing with, or thinking of, ethical and aesthetic judgments. I submit that the diagnostician's evaluation, "In this particular patient the fever is more important than the rapid pulse in summarizing the disease picture in order to attempt to arrive at a diagnosis," is of a somewhat different order and I believe we can attempt a formulation of how to test its validity.

The judgment "more important" implies something that is not in "more beautiful" ("this picture is more beautiful than that one"). It implies an end in view. If it is more important, it is more important for some purpose, the purpose being, of course, a step in arriving at a diagnosis.

It also implies a study of experience. There is no experience postulated or involved in "this picture is more beautiful than that one," although there may be in "it is better to be honest than to be rich." What is the content of the experience by which I make the evaluation "fever is more important than rapid pulse"? First, I do it on the basis of my knowledge of physiology. A temperature of 98.4° F. is a constant for the human body, from birth to old age, year in and year out, through the entire twenty-four hours, with such slight deviations as are known and do not fall within the definition of the term fever. A rise of even one degree has had definite significance in my experience in every case in which I have studied it completely. It may mean bacterial invasion or a neoplastic growth, the first possibility being overwhelmingly in the statistical preponderance. A fever almost never means nothing. A rapid pulse, on the contrary, while it may go with any of the things which cause fever, may also occur in purely nervous states. In any group of a hundred normal individuals you are almost certain to find two or three who have always had a constantly rapid pulse.

It is unnecessary to elaborate this thesis further. Every doctor can supply more reasons from instances or principles of his own experience. Some might even disagree with the entire evaluation and judge that the rapid pulse is more important than the fever. But that is beside the immediate point. The immediate point is that we do have reasons for making this evaluation. The reasons are in our experience and can be enumerated in the form of principles of physiology and pathology in which case the probandum takes on the aspect of an hypothesis, or in the form of a succession of instances all of more or less the same character, in that they pointed to the conclusion that this symptom was important, in which case the probandum takes on the form of a generalization. It might even, in some instances, taken on the form of a primitive.

Furthermore, and this is significant in diagnostic thinking, whatever it is, it is comparative. To say "fever is more important than rapid pulse" means you have made a summary of the reasons for the hypothesis, or the instances of the generalization for both fever and rapid pulse, and have decided that one outweighs the other. In making this part of the evaluation you are guided by the circumstances of the particular case. Other data in the case lead you to make the evaluation. For instance, if the thyroid were enlarged, you might consider the rapid pulse more important than the fever.

Like the judgments for all probanda then, the rules for reasoning in making an evaluation are not hard and fast. But although I know of no inclusive name for them, I submit that they partake of the nature of a comparative hypothesis or a comparative generalization.

VI. Summary of Logic and Diagnosis

The diagnostician, in order to attain his objective, must go through a process of reasoning. This process should be ordered by the discipline of logic, which has been gradually developed by the best minds from the time of Plato and Aristotle to our own, and is still developing.

Logic concerns itself with reasoning containing inference. Inference is the transition from data to conclusion.

Logic is the attempt to formulate methods of reasoning in order to establish validity.

The object of a process of logical reasoning in diagnosis is not necessarily to establish certainty or finality but to arrive at validity. Validity in a diagnostic conclusion tells you what you do know, what you can know, what you do not know, and what you cannot know about the nature of the illness of a given person.

I. Fundamental data.—

Categories—the enumeration of conceptions.

Definition of terms.

Dichotomy, or division, or separation of term from content so that they can be examined.

Fallacies of definition.—(1) Violation of the requirements of definition
(2) Factition. (3) Emotional thinking.

II. **Deduction** is the method of logic which moves from the general to the particular.

Deduction uses propositions and syllogisms.

A proposition consists of two terms (subject and predicate) connected by a copula (verb).

A syllogism consists of two propositions leading to a conclusion.

Fallacies of Deduction.—The formal fallacies concern the syllogism. They are illicit process, undistributed middle and four terms.

The verbal fallacies are accent, amphiboly, composition and division, dicto simpliciter, equivocation, contradictory premise, homonymy, paronymous terms, and poisoning the wells.

The material fallacies are accident, converse accident, false cause, irrelevant thesis, irrelevant evidence, neglected aspect, hypothesis contrary to fact, hasty generalization, ignoratio elenchi.

III. *Analogy* is the method of logic which moves from particular to particular. It attempts to arrive at validity or explanation by demonstrating the similarity between a particular subject which is under dispute or is not clear and another particular subject, well known or clear.

IV. *Induction* is the method of logic most used in scientific thinking, hence in diagnosis. Its reasoning moves from the data (phenomena) to a conclusion (law, diagnosis). In doing so it observes the canons of agreement, difference, variation, residues, and concomitant variation.

V. Another general division of logic pertinent to diagnosis concerns the nature of proof. It is the attempt to elucidate the causal relationship between phenomena. Or to put it another way, it is the attempt to reduce so far as possible with consistent thinking, probability to certainty. It analyzes the reasoning processes which lead men to formulate hypotheses, generalizations, theorems, and evaluations.

The Steps in Diagnosis, the positive reasoning processes demanded in each one, and the logical pitfalls, or fallacies, to be assessed in each one, are as follows:

I. ACCUMULATION OF DATA about the individual patient—history, physical examination, laboratory examinations.

A. *Constructive reasoning* processes involved:

- (1) Trained sense perception—observation, inspection, palpation, auscultation.
- (2) Definition. Accurate recording and description of findings.

B. *Destructive reasoning* processes, or fallacies which may lead to error in this step:

- (1) Omission of important data; omission of an important part of the examination.
- (2) Misinterpretation of data; finding a sign that is not present.
- (3) Dependence on others (laboratory workers) for important data. Acceptance of other's interpretation of x-ray, electrocardiogram, reading into a record something more than is there.

II. EVALUATION OF DATA.—Determining which symptoms and signs are the most important, which are relevant to the diagnosis. Selecting the pathognomonic phenomena in the particular case. Building up a picture, an outline, a cameo of the essence of the clinical situation.

A. *Constructive reasoning* processes involved:

- (1) It is essentially a process of dichotomy under the general heading of definition.
- (2) It requires judgment, based on experience and wisdom (for which there is no substitute in armchair reasoning).

B. *Destructive reasoning* processes, or fallacies which may lead to error in this step:

(1) Accent. Especially:

- a. Overemphasis on some minor part of the examination—faddist interpretation, the little learning that is a dangerous thing. Liable to happen in any department, but perhaps particularly with blood chemists. As another example, evaluation of the symptom of fatigue by the vitaminist.
- b. Dependence on unreliable signs. Putting more on the sign than it can bear—e.g., Kronig's isthmus, Grocco's triangle, extra heart sounds, "shift to the left of leucocyte counts."

(2) Accident. (See page 32.)

(3) False cause. (See page 32.)

(4) Hypothesis contrary to fact. (See page 34.)

(5) Hasty generalization. (See page 43.)

III. PREPARATION FOR DIFFERENTIAL DIAGNOSIS.—Compiling a list of all the pathologic conditions which could by any possibility explain the summary of the evaluation of symptoms and signs made under step II.

A. *Constructive reasoning* process involved—statistical or proportional generalization. Part II of this work furnishes a statistical evaluation of symptoms. The rest of the book is devoted to signs, placing them as nearly as experience makes possible on a statistical basis.

B. *Destructive reasoning* processes, or fallacies, which may lead to error in this step.

(1) Factition. False pathology, such as "Chronic appendicitis causes chronic indigestion." "Pus in the urine is due to cystitis." Vagotonia induces excessive sweating." This is the pitfall of the faddist. (See page 14.)

(2) Emotional thinking. Forming a theory unrestrained by data.

(3) Inadequate list of possibilities. Not thinking of enough things.

IV. DIFFERENTIAL DIAGNOSIS.—Fitting the data—symptoms and signs—of the individual patient to a known disease pattern established by pathology.

A. *Constructive reasoning* processes involved:

(1) Induction—Application of the Canons of Agreement, Difference, Variation, and Residues. (See page 23.)

(2) Hypotheses and probabilities. (See page 37.)

(3) Probable inference.

B. *Destructive reasoning* processes, or fallacies, which may lead to error in this step:

(1) Fallacy of false cause. (See page 32.)

(2) Fallacy of irrelevant evidence. (See page 33.)

(3) Fallacy of neglected aspect. (See page 34.)

- (4) Hypothesis contrary to fact. (See page 34.)
- (5) Hasty generalization. (See page 43.)
- (6) Ignoratio elenchi. (See page 21.)
- (7) Non-sequitur argument. (See page 36.)

V. SUMMATION.—This is an optional step. With your conclusion before you, test it by deductive and syllogistic reasoning.

Reading List of Books on Logic and Scientific Method

I. Textbooks

- Castell, Alburey: *A College Logic*, New York, 1943, The Macmillan Co.
Very stimulating and fresh presentation.
- Eaton, Ralph M.: *General Logic*, New York, 1931, Charles Scribner's Sons.
Best of the larger elementary texts. Good as supplementary reading to Castell.
- Patterson, Charles H.: *Principles of Correct Thinking*, New York, 1942, Longmans, Green & Co.
Valuable for the illustrative cases and excerpts of original scientific and other argumentative literature.
- Robinson, Daniel Sommer: *Illustrations of the Methods of Reasoning*, New York, 1925, D. Appleton-Century Co.
Classic examples of the various methods of reasoning. A source book. Indispensable.

II. The Original Literature of Logic

- Aristotle: *Works*. Edited, with an excellent introduction, by Richard McKeon. New York, 1941, Random House.
*Contains the *Organon* complete.*
- Bacon, Francis: *Novum Organon*. In *English Philosophers*. The Modern Library, Oxford Clarendon, 1889.
- Bradley, F. H.: *The Principles of Logic*, London, 1922, Oxford University Press.
A critique of classical logic.
- Dewey, John: *How We Think*, Boston, 1933, D. C. Heath & Co.
- Keynes, James Maynard: *A Treatise on Probabilities*, The Macmillan Co., 1921.
- Mill, J. S.: *A System of Logic*, Harper, 1870.
This is out of print and difficult to obtain, but very valuable for the inductive methods.
- Ogden, C. K., and Richards, I. A.: *The Meaning of Meaning*, ed. 6, New York, 1943, Harcourt, Brace & Co.
*Contains as a supplement F. G. Crookshank's essay, *The Importance of a Theory of Signs and a Critique of Language in the Study of Medicine*. This is a must for the philosophic physician.*
- Plato: *Euthyphro, Timaeus, Theaetetus, Symposium*, The Macmillan Co., 1935.
- Schiller, F. C. S.: *Formal Logic*, ed. 2, London, 1931, The Macmillan Co.
The Testament of the "new" logic.
- Whitehead, A. H., and Russell, Bertrand: *Principia Mathematica*, Cambridge University Press, 1910.

III. Scientific Method

- Cohen and Nagel: *An Introduction to Logic and Scientific Method*, New York, 1934, Harcourt, Brace & Co.
A textbook in a class by itself.
- George, William H.: *The Scientist in Action*, New York, 1938, Emerson Books, Inc.
Well-planned and stimulating work. Do not let the title antagonize you.
- Pearson, Karl: *Grammar of Science*, Everyman's Library.
- Whitehead, A. N.: *Science and the Modern World*, The Lowell Lectures—1925, New York, 1941, The Macmillan Co.
Contemplative and undogmatic.
- Wolf, A.: *Essentials of Scientific Method*, London, 1925, George Allen and Unwin.

Chapter 2

THE ORGANON OF DIAGNOSIS

"The scholastic sees the world of reality with the triple eye of sense, reason, and faith. These organa are distinct and each in its limited sphere independent." (*New International Encyclopedia*.)

We will assume that the steps in diagnosis which were suggested in the last chapter have been accepted by you, my reader, as a sound and valid outline of the mental processes which every physician goes through in making a diagnosis. They are:

I. The accumulation of data.

II. Judgment of data. Evaluation of relative importance of different symptoms and signs.

III. Differential diagnosis—listing of all the diseases which the specific case could possibly resemble.

IV. Reasoning by exclusion by the canons of agreement, difference, variation, and residue, until the diagnostician is satisfied either that the case under consideration can be fitted into a definite disease category or that it may possibly be one of two or more diseases or that its exact nature cannot be determined.

In the first chapter we considered the general mental or reasoning processes involved in each of the steps.

In this chapter I purpose to consider them again with special reference to the more technical details and pitfalls (fallacies) involved.

I. ACCUMULATION OF DATA

1. *The anamnesis, or history:* The patient's recital of the symptoms and chronology and past illnesses. (For full outline of history record see pp. 77-156.)

2. *The physical examination* of the patient's body by means of the physician's senses of sight, touch, and hearing (sometimes smell)—inspection, palpation, percussion, and auscultation. (For full outline see pp. 157-173.)

3. *Chemical and microscopic examination* of urine, blood, sputum, gastric contents, stool, etc.

4. *X-ray examination*, if indicated.

5. *Special procedures*, such as electrocardiograph, basal metabolism, skin tests, etc., when indicated.

6. *Examination by specialists.*

II. JUDGMENT OF DATA

Judgment of Trustworthiness and Reliability of Data

Obviously the correctness of a diagnosis must depend fundamentally on the premise that the examiner has all the data, or all the essential data, that

nothing essential is omitted, and that the data are real and reliable. Reasons for failure to accomplish this fundamental are suggested as follows:

The data in the history constitutes perhaps the greatest stumbling block in this category. They are almost automatically unreliable because they are the record of events of highly emotional content to the narrator and are strained through his personality, and yet are of primary importance. "A good history," as the saying is, "is the guide to proper diagnosis." Nothing takes more training than to obtain a good history. Much depends on the questions asked. There are times when to let the patient have his head is fatal, other times when it makes the diagnosis.

Many histories are unreliable because they take on the aspect described by Dr. Robert Hutchinson (*Principles of Diagnosis*, Brit. M. J., March 3, 1928).

"The description of a disease in books is like the description of a person wanted by the police, or the word-painting of scenery in a novel—it rarely gives us any real mental image of the thing described. As Montaigne says:

"Like him who paints the sea, rocks, and heavens, and draws the model of a ship as he sits safe at his table, but send him to sea and he knows not how or where to steer, so doctors often make such a description of our maladies as the town crier does of a lost dog or donkey, of such a color, such ears, etc., but bring the very animal before him and he knows it not for all that.'"

Lack of frankness on the part of the patient, especially as to venereal diseases, is familiar to all experienced diagnosticians. "At times patients deliberately suppress facts; they may deny a history of gonorrhea, and diagnosis is difficult owing to the fact that the gonococcus may for long periods remain latent in the body. In two of my cases of chronic arthritis the gonococcus was cultivated from the prostatic secretion over twenty-three years after the original lesion."—Dr. Julius Burnford (*Brit. M. J.*, Feb. 22, 1930).

Physical Examination

Slipshod Methods.—Nothing illustrates slipshod methods in the physical examination better than the Argyll-Robertson pupil. The average physician in a fully lighted room will cover the patient's eyes with his hand, or worse, press the eyelid down and then withdraw the hand and observe the pupillary reaction. If he does not see it very well, he reports that it contracts. Or if it is small on first inspection, he says it is fixed. And then, except the exceptional examiner, he neglects the distance test entirely, especially if the patient has a tabetic gait.

Finding a Sign That Is Not Present.—I believe that the most frequent and by all odds the most serious mistake in the physical examination is to find a sign that is not present. The opposite mistake—overlooking a sign that is present—is usually emphasized. But to find a sign when it is not there commits the diagnostician (and the patient) to far more serious consequences. Unnecessary operations will come to mind immediately—a phantom mass is found, an exploratory laparotomy follows, and nothing is found. And that, in the impressive language of our day, ain't fun for anybody, patient or anyone else.

This is, of course, the common error of the beginners. The sophomore medical student goes through a course in physical diagnosis, examines a number of patients with heart murmurs, and then is asked to examine and report on an unknown. He feels he must find something; it makes him look impressive. It takes courage and experience to say, "The heart is normal." So he reports a murmur.

The importance of the consequences cannot be exaggerated.

Suppose it were an applicant for life insurance, and the examiner found a heart murmur. The applicant would be unjustly denied insurance.

Suppose the diagnostician finds râles in the apices, and a patient is removed from his business to spend a year (or sufficient time until the diagnosis of tuberculosis is rejected) at bed rest. That is a serious consequence of finding a sign that is not there.

Or an enlarged spleen is found and the patient undergoes a long, expensive, and potentially dangerous course of radiation.

A lump is found in the breast and a perfectly innocent breast is removed.

I used to meet frequently in consultation a colleague who had this habit overdeveloped. I remember one woman in whom he insisted that râles were present: twenty years later she is perfectly healthy and never had any treatment for tuberculosis. He vehemently and even angrily insisted on one occasion that there was an enlarged kidney, probably a hypernephroma: nobody else could find it. I still see this patient who, after a number of years, still has his kidney, has no trouble from it, and has never had a knife laid upon him.

I used to attend a three months' service, beginning October first, at a city General Hospital. Once I found I had inherited a patient who had been in bed on the service for nearly two months. He had a fever and pain in one leg and hip. The diagnostic label on him was "acute rheumatic fever," arrived at apparently because the previous staff attendant had found a systolic murmur in his heart. I found no murmur and began to revise the diagnosis. The man had been lying there seven weeks and no one had taken an x-ray picture of the offending hip, and no one had asked for a leucocyte count, because the alleged and nonexistent murmur had closed their minds to any other possibility than acute rheumatic fever. As a matter of fact he had an osteomyelitis so long neglected that an amputation at the hip had to be performed—a fairly serious consequence of finding a sign that was not there.

Why do we make these mistakes? There are several reasons. *First*, I think, is lack of self-assurance. There is a funny sound there—maybe it's a murmur—better call it a murmur. The diagnostician who thinks that way does not know a murmur when he hears one. *Second*, I suspect we are afraid somebody else—one of our rival consultants—will find a sign we have missed. So we beat the rival to it by finding all the signs there are. It takes just as much courage to say "no" as to say "yes." *Third*, the patient leads us astray. He has so many symptoms that we feel we must find something to account for them. Is it possible for a patient to be as fatigued as this patient claims to be

and have no sepsis or tuberculosis? Or that agonizing pain in the abdomen—one hardly has the face to say that there is not only no tumor there, but not even any rigidity.

This habit of finding things that are not there may bring the greatest humiliation to the diagnostician. When he has found a sign, he is committed to something. The exploratory operation or the autopsy or time may show him up. Remember if you do not find a sign, nobody can ever prove you did: the sign may be there, but if you did not find it, you did not find it. But if you find a sign that is not there, you may be shown up any time. That is easy to prove.

Omission of Important Data—Incomplete Records, Failure to Make a Thorough Examination.—This is the fault that is most often emphasized by teachers and preachers on diagnosis; but as I have said, in my experience, it is not so often serious as finding a sign that is not present. Of course it does occur and all too frequently. As an example I quote a report by Dr. James S. Ford (Proceedings of the National Association for the Prevention of Tuberculosis, 1915) of his survey of the examinations made by a number of physicians on persons suspected of having tuberculosis. Here is a common condition for which we have four established and reliable methods of diagnosis, all of which should be used in every case: history, physical examination, x-ray picture, and sputum examination, and a fifth, the tuberculin test, which can be used with proper precautions in many cases. That the report dates back to 1915 need not make you disregard it: such procedures still go on.

"1. The 31 nontuberculous cases of the series consulted 56 different physicians, of whom:

"a. Thirty-seven (66 per cent) made a physical examination, only one of these in addition making an x-ray study;

"b. Six (10.7 per cent) examined the chest and the sputum;

"c. Six (10.7 per cent) examined the chest, took the temperature, but made no sputum examination;

"d. Four (7.1 per cent) examined the chest, took the temperature, and examined the sputum;

"e. Three (5.3 per cent) made no examination whatever.

"2. The 148 incipient cases consulted 254 physicians, of whom 160 (62.9 per cent) made an examination of the chest only, and 11 of these made this examination through the patient's clothing. As for the remainder:

"a. Two (0.8 per cent) took the temperature only;

"b. Three (1.1 per cent) examined the sputum only;

"c. Twenty-seven (10.7 per cent) examined the chest and sputum, but did not take the temperature;

"d. Fifteen (6 per cent) examined the chest, took the temperature, but did not examine the sputum;

"e. One (0.4 per cent) took the temperature and examined the sputum, but made no physical examination;

"f. Seven (2.8 per cent) examined the chest, took the temperature, and examined the sputum;

"g. Thirty-nine (15.3 per cent) made no examination whatever, but treated the patients for various ailments, such as 'run down,' anemia, malaria, and 'walking typhoid.'

"Here we have only 3 per cent of the doctors making use of most of the diagnostic methods available, while over five times that number made absolutely no effort to find the seat of the trouble, but, by their negligence or carelessness, allowed a case with an excellent opportunity for arrest and a return to normal life to go on to a far-advanced stage.

"The figures relative to the moderately advanced and advanced cases are just as startling in the matter of errors of omission as are those just quoted, but it will avail nothing to burden you with them. We shall, however, give you the results of the several means of diagnosis made use of in the 1,000 cases as a whole. The 1,000 cases consulted 1,940 physicians, of whom 1,085 (55.1 per cent) made a physical examination only, and of this number, 151 did not deem it worth while to have the patient strip; 13 (0.7 per cent) took the temperature only; 14 (0.7 per cent) made a sputum examination only; 381 (20 per cent) made a chest and sputum examination; 114 (6 per cent) examined the chest, took the temperature, but made no sputum examination; 3 (0.02 per cent) took the temperature and made a sputum examination, but made no physical examination; 133 (7 per cent) made a chest examination, took the temperature, and examined the sputum; 197 (10.2 per cent) made no examination of any kind.

"Comment on the foregoing figures is scarcely necessary. The contrast of 133 out of 1,940 physicians (7 per cent) making use of simply the fundamentals in the diagnosis of pulmonary tuberculosis, as against 196 men (10.2) who made no examination whatever is so striking as to be almost unbelievable."

Dr. Horace L. Foss (*The Element of Error in Abdominal Diagnosis*, Philadelphia Academy of Surgery, March 6, 1916) wrote:

"An investigation of the question revealed that in making general physical examinations the commonest details missed ran as follows:

- "Small ovarian cysts and other pelvic masses.
- "Small adenomata of the thyroid.
- "Small hyperplastic thyroids in early hyperthyroidism.
- "Enlarged cervical, axillary, and other lymphatic glands.
- "Presystolic and other valvular murmurs.
- "Absent knee jerks.
- "Thickened seminal vesicles.
- "Splenic enlargements.
- "Epigastric masses in carcinoma of the stomach.
- "High rectal metastases in carcinoma of the stomach.
- "Nye signs (in high tabes and other cord and cerebral lesions).
- "Sclerotic pallor suggesting the anemias.
- "Rectal and rectosigmoid masses in carcinoma of the rectum."

With reference to the last item and the dictum that has been dinned into our ears for generations, "Always make at least a digital examination of the rectum," I recall a consultation where the consultant put on a rubber glove, made a rectal examination, and reported there was nothing present, as he stripped off his glove. Another consultant rescued the glove, turned it right side out, and pointed to blood on the index finger.

For years it was a favorite habit of the medical clinician to bring into the amphitheater for the benefit of the class a patient with several laparotomy scars, whose real trouble was the gastric crisis of tabes.

Dr. J. W. Nuzum ("Needless Surgical Operations From Failure to Recognize *Tuberculosis Dorsalis*," *J. A. M. A.* 66: 482, 1916) found in one thousand tabetics that 8.7 per cent had been subjected to laparotomy. The diagnoses in the order of frequency were: peptic ulcer, gallstones, appendicitis, renal calculus, and ectopic gestation.

Yet all the examiner has to do to avoid such mistakes is to tap the knee and examine the eyes. Apparently surgeons have learned to do this: we find, I think, fewer of these choice multiple laparotomy-scarred victims than we used to.

Still another frequently missed diagnosis was pyelitis. Dr. Arthur F. Byfield (*M. Clin. North America* 3: 1522, May, 1920) wrote under this heading:

"Pyelitis, with irregularly recurring pain, fever—often with chills or chilliness and sweating—due to the kinking of the ureter, with subsequently infected urine, of a low-lying kidney. We have seen several instances of this condition in the past few months. One case was diagnosed and treated as malaria, the misplaced kidney having been called the spleen; the other was regarded as a tuberculous pleurisy or a pulmonary tuberculosis. In both cases the diagnosis was established to our satisfaction, at least, by thorough urologic studies and by the results of treatment (padded corsets, forced feeding, etc.)."

Here all the diagnosticians had to do to avoid the diagnostic error was to look at the urine collected in a conical glass. He did not need a chemical or microscopic test, or a centrifuged specimen—just a gross specimen in a urine glass.

Omission of data may be due to *turning over an essential part of the examination to someone else*. Still on the subject of pyelitis I have a vivid recollection in my own experience to illustrate this. A little girl began to run a fever. She was taken to a hospital where all sorts of examinations were made, but nothing markedly abnormal was found. Finally, the otologist consultant thought the eardrum was sufficiently congested to warrant paracentesis. He said he drained pus—you know, blood mixed with pus. But the fever did not come down. Then an ear specialist was summoned from a distant city. Before he decided to open the mastoid he inquired into the condition of the urine. The laboratory had reported on five specimens—all normal. But when the consultant from the distant city *looked at the specimen himself*, he found a layer of pus the thickness of a fingerbreadth in the bottom of the centrifuge tube.

Dependence on Methods That Are Intrinsically Unreliable.—This is particularly likely to be the fault of the younger diagnostician. He reads, or is exposed to, an enthusiastic description of some sign, such as Grocco's triangle, and works at demonstrating it and if he finds it, lays great stress on it. I have seen them spend more time on the triangle than on the signs over the fluid. And even demonstrate the triangle when no dullness is present on the contralateral side. As time goes on, the experienced diagnostician throws this luggage overboard. He wants his signs to be all wool and a yard wide.

Why attempt to outline the borders of the heart by percussion? It cannot be done. Anyone who attempts it is liable to a gross error of 75 per cent.

This has been demonstrated over and over again by the comparison of percussion markings with x-ray plates. Why then try it at all? We can locate the apex beat by inspection and palpation with less than 10 per cent of error. That is the only determination of the heart size we can make by physical diagnosis. We must infer the rest or depend, such as they are, on the x-ray findings. Let us acknowledge this and do it.

Another instance is the use of the percussion of Krönig's isthmus for the diagnosis of tuberculosis. In the first place, not one out of a hundred men can ever learn to be an accurate percussor. Not one out of a thousand can learn to be sufficiently accurate a percussor to outline Krönig's isthmus. Even when accurately outlined its significance is very doubtful. Yet we have tuberculosis specialists solemnly hammering away in order to record this thoroughly unreliable fact, teaching others to do the same. As an example of the way an experienced diagnostician depends on nothing but dependable methods, contrast the five diagnostic criteria Dr. Lawrason Brown set up for a diagnosis of tuberculosis. The diagnosis of tuberculosis cannot be made, he says, unless some of the following five things are present:

1. History of hemoptysis.
2. History of pleural effusion.
3. Tubercle bacilli in the sputum.
4. Râles on auscultation (over a period of time) .
5. Spots of tubercle in the x-ray film.

Look that list over. Every one of them solid to the bone.

Think of that and think of all the fine-haired methods the average tuberculosis expert dilates upon. Dr. Brown has even left out temperature, history of loss of weight, fatigue, and cough. All those things may be deceptive. In physical diagnosis the only sign he depends on is the râle. That is the result of a long experience and the discarding of all less dependable methods.

The same thing applies with equal force to other fields—the doubtful value of liver function tests, the interpretation of linear lines (the fan) on the x-ray plate as indicative of pulmonary tuberculosis, the nonspecificity of skin tests for food hypersensitiveness, etc.

The Litten phenomenon is another that takes up space in the textbooks, but none in the impedimenta of the experienced diagnostician.

Some specialists often think it is impressive to expatiate on the significance of some slight variation from normal. I quote from a review of a treatise on electrocardiography:

"The reviewer would take mild exception to such statements as, 'The recognition of early and relatively mild changes in the myocardium may be, we believe, greatly facilitated if the electrocardiographer pays more attention to minor deviations from the normal.' This is 'heady medicine,' and tends to encourage those who make too much of too little in the interpretation of electrocardiograms. Anyone who fathers a book on this subject is chagrined more by those who see too much in a tracing than by those who see too little."

Turning Over an Essential Part of the Examination to Someone Else.—This is working with false data. The danger is inevitable in modern medicine

when so many examinations have to be delegated to one kind of a laboratory or another. It is well that the modern diagnosis depends so largely on data that the physician must accumulate for himself—history and physical examination. And he can look at the x-ray plates himself, as well as the electrocardiographic records: that is what makes them so valuable. For this reason I think the diagnostician should make the urinalysis himself and estimate the hemoglobin and at least look at the gross specimen of stool, sputum, and gastric contents. For the other laboratory reports he must cultivate a healthy skepticism, and he should realize that it is healthy.

As an illustration: My friend, the late Dr. Leroy Crummer, told me that he had been having his blood chemistry done by a young woman. One day his wife gave him a sample of silk to match at a downtown department store, and since the technician spent all her time matching colors, he delegated the commission to her. She returned with a half bolt of goods that was a whole octave off in color! And Dr. Crummer had been depending on laboratory reports from her, reports the validity of which rested entirely on her ability to match colors.

III. DIFFERENTIAL DIAGNOSIS

Listing of all the diseases which could possibly be of the nature of the specific case under consideration for diagnosis.

There is perhaps no exposition that can improve the diagnostician's expertness in this step in the procedure. Experience alone adds to his accomplishment. The more he learns of pathology, the more autopsies he witnesses, the more surgical operations, the more clinical cases he carries through to a successful or unsuccessful conclusion, the more this particular part of his mind, the storehouse of memories, will become classified and orderly and useful. Such suggestions as I shall make below are necessarily sketchy and tentative.

In making his list preparatory to the next step in diagnosis, which is exclusion of all unlikely candidates, he strives for two ideals: (1) completeness and (2) reality.

All the mistakes which are made in this step arise from either incompleteness (*"not thinking of enough things"*), or the habit of indulging in *mythological abstractions instead of real pathology*.

How to guard against incompleteness I do not know. But I do know that, in my judgment, the most brilliant diagnosticians of my acquaintance are the ones who do remember and consider the most possibilities. Even remote ones should be brought up, even though they may be immediately rejected.

Three procedures which can be cultivated as helpful aids are:

1. **Analysis of the data of the case under consideration.** The questions which I have suggested under the heading of evaluation on page 61 are helpful: "Is it organic or functional? Or mixed? "If functional, is it a neurosis (migraine, epilepsy, tic douloureux, etc.), or a psychoneurosis?" "Is the circulatory system primarily involved? or the nutrition?" etc.

"Has the patient ever lived or traveled in the tropics?"

"What is his avocation? It may be more important than his vocation."

"What is the etiology of the condition?" If it be a psychoneurosis, or an organic condition, complicated by a psychoneurosis, this may be very important in completing your classification.

Such analytic questions are merely suggestions. They can be extended. The more complicated and difficult the case, the more extended they should be.

2. **Statistics.**—There is no department of medical literature that is more impoverished than that of clinical statistics. It is hard work to sit down and go over a series of a hundred cases on the basis of what a single symptom or a single sign has eventually, at the autopsy or elsewhere, turned out to mean. In the chapter on symptoms I have gathered all the literature I could find on the subject as applied to each symptom considered, but there are many gaps. In all the other chapters I have reported what information I could find available with the same thesis in view.

Two maxims have proved constantly helpful:

a. "Common things most commonly occur."—Samuel Gee.

Or, in the words of Robert Hutchinson (*Principles of Diagnosis*, Brit. M. J., March 3, 1928): "Don't diagnose rarities. I was associated for a while in my early days with a physician who had acquired a reputation in the diagnosis of unusual and rare cases, although, as a matter of fact, he was more often wrong than right. I remember going round the wards with him one day when he pointed to a sudden elevation of temperature in a chronic case of pulmonary disease and inquired its cause. I replied that I believed it was due to the patient having developed an ischiorectal abscess, as he had a tender swelling in the usual situation. 'Well,' he replied, 'I have seen an empyema point there.' When at a consultation I hear a doctor begin, 'I once saw a case,' etc., I know he is going to make a bad diagnosis. Cases so uncommon as only to be seen once are not likely to be seen again."

b. "Beware the man of one case." This is merely a corollary of the above. I refer to the consultant who once saw a patient who had a perforated appendix in which a chewed toothpick was found in the abscess, and it developed he was a great toothpick chewer. I refer to an actual experience of mine. He could never forget that case. He taught students also, worse luck for them. And the amount of time he has wasted in my presence, asking patients if they often chewed toothpicks, makes me groan in retrospect. The instance is an extreme one, but it served to illustrate the physician who is always saying, "I had a case once—" etc. He violates the principle of completeness in listing of diagnostic possibilities because he cannot be brought to consider any other possibility than that one case.

The specialist is particularly liable to the danger of turning into "the man of one case." "To the cardiologist few hearts are healthy: to the tuberculosis expert no lung is sound. The syphilographer sees disease only in terms of syphilis: the psychoanalyst only in terms of sex." (Robert Hutchinson.)

"The specialist on diabetes has been known to let his patient die with an unrecognized heart lesion while engrossed in keeping her blood and urine

"sugar-free." (Dr. Albert S. Welch, *The Relative Frequency of Disease Conditions*, J. Kansas M. Soc. 27: 266-267, August, 1927.)

3. **Comprehension of experience** is a principle which must be taken into account in the regular experience of the general internist in the field of diagnosis. He cannot limit himself to the subjects considered in the textbooks of his specialty. His field necessarily included that of the oculist (glaucoma, headaches, for instance), the aurist, the laryngologist, the dentist, the obstetrician, the gynecologist, the proctologist, and the urologist.

As an illustration, when I was inducted into military service in 1917, I was assigned to the medical service at Fort Sam Houston, Texas. A few days after my assumption of duties I was approached by the Senior Dental Officer, who said he understood I was an eminent specialist on stomach disorders and requested me to examine his wife. She was having a digestive upset consisting largely of vomiting, to which she was thoroughly entitled, as I found as soon as I had examined her uterus, which was pregnant indeed. And remember, this was a dental officer. And I was supposed to be just a stomach specialist.

4. **Reality.**—I refer to the unhappy habit many practitioners drop into of acquiring mythology and not pathology. I have discussed it under the heading of definition in Chapter I (p. 10).

I once knew a colleague who late in life had his head turned by reading a German monograph on perisplenitis: every third patient he subsequently had was labeled perisplenitis.

"Don't mistake a label for a diagnosis. Such 'diagnoses' as 'gastritis,' 'neuritis,' 'influenza,' 'neurasthenia,' are more often than not mere labels; they have no essential relation to reality. It may be necessary in the exigencies of practice, and in order to satisfy the patient's mind, to use such labels for a time, but don't let them deceive you into thinking that you understand the nature of the case. Be mentally honest." (Robert Hutchinson.)

5. **Evaluation of Data.**—After he has made a judgment on the data before him—is sure it is accurate, reliable, valid and that none of importance has been omitted—the diagnostician begins to fit them into causal relation to the diagnosis and here he must use judgment of evidence—such as to determine which data are of primary, which of secondary, importance, whether the cause is sufficient to account for the effect, etc.

Judgment of Primary or Secondary Value of Data

I can illustrate this by referring to the clinical reports of a by-gone age which always contained notations as to how much indican was present in the urine. Some diagnosticians considered this of great importance: others did not pay any attention to it at all. The latter have, in the light of history, turned out to be right, at least indican determinations are no longer made.

Note, however, that the presence of indican was a fact: it was a valid datum. It just doesn't happen to mean anything.

As another illustration—take a patient who has a fever and nothing else. He has a negative Widal test, negative brucella agglutination test, no tuber-

culin skin reaction, negative chest x-ray findings, etc., but the fever outweighs all the negative evidence in deciding that the patient has an infection.

Not that negative evidence is always of secondary importance. Professor Chvostek, of Vienna, by example, would never make a diagnosis of Addison's disease if pigmentation was absent from the mucous membrane of the mouth.

A good example of data of primary and secondary importance is furnished by Lawrason Brown's standards of symptoms and signs necessary for a diagnosis of tuberculosis (see page 417).

Judgment of Cause and Effect

The object of the research scientist is to reduce this judgment to the proof that one cause produces one effect. The method for accomplishing this is the elimination of variables.

The diagnostician's field not being that of experiment, he cannot hope to attain to such unity in any considerable proportion of cases. Yet he must try to relate cause to effect and in doing so he uses the method of the experimental or "pure" scientist of reducing the number of variables to the lowest possible.

For instance, the effect is hematemesis, the possible cause is peptic ulcer. But the effect variables are that the ulcer also produces epigastric discomfort and possibly vomiting. The cause variables are that the state of the weather, the amount of gastric secretion, and the food eaten may diminish or increase the effects.

The equalization of variables may be done by several methods. The most important is that of statistics. Another, which is merely a variation of statistics, is that of controls. The diagnostician cannot set up real control but only that of experience.

Chance.—Two rival marksmen, "Chance" and "Agent," fire simultaneously at the target. A single bullet is found to have hit. The judge, after looking at a memorandum, announces "Agent" is the winner. Whenever in Nature the cause for any effect is known—cold freezes water, fire burns wood, pressing the button rings the bell—the knowledge has come from a contest of this kind. The judge has "Chance's" shooting record on his memorandum, nothing more. It may read: "Chance" can hit this target once in a hundred times." The record of "Agent" is unknown: he has never shot before. Translated into terms of medical investigation the memorandum would read: "This rise in blood pressure in patients after receiving the new drug has been found to occur by chance alone, once in a hundred times." This figure is called in statistical language " $\frac{1}{2}$ P."

Rules regarding chance:

1. If $\frac{1}{2}$ P is 2.5 per cent (5 hits in 200 shots) or smaller, decide against chance.

2. If $\frac{1}{2}$ P is larger than 2.5 per cent, throw the case out of court (do not decide in favor of chance). (2.5 per cent is arbitrary, but is agreed to by all experts in the statistical field.)

In clinical practice, in diagnosis, chance plays little if any part. The classification "*chance*" must be broken down into that of rare but possible agents. For instance, the diagnostician is called upon to identify the agent which caused the vomiting of blood. Experience teaches him that peptic ulcer is the cause in 78 per cent of cases, cirrhosis of the liver in 9 per cent, cancer in 8.5 per cent, vomiting of hemorrhage from the mouth or respiratory tract in 3.5 per cent, and miscellaneous causes (rare tumors, purpura, sepsis, myelogenous leucemia, etc.) in 1.5 per cent. Now the 1.5 per cent could be called chance ($\frac{1}{2}$ P) and since it is below the arbitrary 2.5 per cent that is allowed for chance in calculations of experiments it could be disregarded. But the diagnostician cannot disregard it. If his patient is twenty-five years old (agent variable 1) and has had a history of discomfort after meals (agent 2) relieved by soda (agent 3), the percentage of probability that the hematemesis is due to peptic ulcer rises to 99.5 per cent. If the patient is fifty years old, has a history of long-continued regular drinking of alcoholic beverages, has a liver palpable and hard below the costal arch, the chances are 99.5 per cent that the hematemesis is due to cirrhosis of the liver with rupture of an esophageal varix. And breaking down the chance group, if the patient has a prolonged bleeding time and an eruption of hemorrhagic spots on the skin, the chance that the agent cause is purpura rises to 99.5 per cent. That is why we say that chance plays little if any part in diagnostic speculations.

Summary of Evaluation of Facts.—An agent may be considered to produce an effect, provided it is determined that it always produces the same effect under the same circumstances. Therefore, as far as possible, variables—amount, time, environment—must be eliminated, standardized or allowed for in concluding the judgment. When multiple agents produce one effect, the proportion of individual influence must be assessed. When a single agent produces multiple effects, the relationship of the agent to each effect must be evident. When multiple agents produce multiple effects, the relative causative weight of each is inevitably a matter of the personal equation of the observer. The result statistics of experience in the past, and the ratio of standard deviation variables must be examined in order to make this personal equation as exact as possible.

ILLUSTRATIVE CASE.—In order to indicate that the methods here outlined have not been adduced by me and deliberately forced to make my point, I present an illustrative case brought forward by another practitioner. It is from an article by the late Dr. Llewellys F. Barker, entitled *The General Diagnostic Study by the Internist* (New York M. J., Sept. 21, 28, and Oct. 5, 1918). Note specially his evaluation and re-evaluation of the data.

CASE.—Male, age 56, manufacturer.

November 4, 1917.

Complaint: Cough; shortness of breath; swelling of abdomen.

Family History: Negative.

Personal History: Always healthy. Formerly, moderate potatorium. Recently, habits good.

Present Illness: Onset in June, 1917, with slight swelling in glands of neck; later abdominal discomfort with alternating diarrhea and constipation; low fever; development of cough and shortness of breath; physician suspected oral sepsis and had roentgeno-

grams of teeth made, revealing periapical granulomas; removal of bridges; gums inflamed; isolation of bacillus with morphology of diphtheria bacillus; extraction of diseased teeth; development of a slight papular exanthem on trunk, forearms, and thighs. Liver found enlarged October 4; on October 21, pleural effusion found on right side; at end of October, fluid demonstrable in peritoneal cavity; also beginning edema of lower trunk and genitalia.

SUMMARY OF PHYSICAL EXAMINATION.—Moderate emaciation; slight fever; one loose tooth still present; moderate enlargement of jugular, retrocervical, and axillary glands; signs of fluid in right pleural cavity and in abdominal cavity; edema of lower trunk; edema of genitals; enlargement of liver and spleen.

REPORTS OF LABORATORY TESTS

Sputum: Negative for tubercle bacilli.

Blood:

R.B.C. 3,820,000 to 4,480,000; Hb. 74-80 per cent.

W.B.C. 10,200 to 16,400.

P.M.N. 78-89 per cent.

Blood culture negative on two occasions.

Wassermann negative.

Urine:

Specific gravity 1.011-1.025.

Oliguria.

Slight albuminuria at times.

A few hyaline casts.

No blood.

Phthalein output 65 per cent.

X-RAY REPORTS

Mediastinum: No large masses seen.

Right Pleural Cavity: Shadow (fluid).

Cardiovascular Stripe: Displaced to left.

Rearrangement of the Data

CASE.—Male, age 56, manufacturer.

Complaints: Cough; shortness of breath; weakness; swelling of abdomen.

Habits: Formerly moderate potatorium; abstainer recently.

Previous Infections: None. Low fever for last four months. Oral sepsis treated. Diphtheroid bacillus isolated from inflamed gums.

Operations: None.

Respiratory System: Cough; dyspnea; fluid in right pleural cavity during past two weeks; sputum negative for tubercle bacilli. X-ray film of mediastinum; no large masses seen. X-ray picture of thorax reveals shadow on right due to pleural effusion.

Circulatory System: Right hydrothorax; hydroperitoneum; edema of lower trunk and of external genitalia. X-ray film of cardiovascular stripe shows dislocation of heart to the left.

Blood System: R.B.C. 3,830,000; Hb. 78 per cent; W.B.C. 16,400; Wassermann test negative; P.M.N. 89 per cent. Glands in neck began to swell and later there was moderate enlargement of jugular, retrocervical, and axillary lymph glands; palpable spleen.

Digestive System: Abdominal discomfort; alternating constipation and diarrhea; periapical granulomas; gingivitis; liver enlarged for past month; fluid in peritoneal cavity recently.

Progenital System: Urine: Specific gravity 1.011-1.025; albumin slight; sugar negative; a few hyaline casts; W.B.C. negative; R.B.C. negative; phthalein output 65 per cent.

Locomotor System: Negative.

Nervous System: Slight delirium at times. Asthenia.

Metabolic and Endocrine Systems: Moderate emaciation; slight fever.

Skin: Papular exanthem on trunk, forearms, and thighs.

TENTATIVE DIAGNOSTIC SUGGESTIONS AT DIFFERENT TIMES DURING THE STUDY BEFORE THE CONSULTATION

1. Oral sepsis with cervical adenitis and metastatic pleuritis.
2. Diphtheria.
3. Pulmonary tuberculosis.
4. Lymphatic leucemia.
5. Syphilis.
6. Aleucemic leucemia.

Unsatisfactoriness of these hypotheses on rational elaboration and attempts at corroboration. Diagnostic perplexity continued.

ADDITIONAL DIAGNOSTIC SUGGESTIONS AT CONSULTATION

Possibility of Hodgkin's disease. Suggestion based upon memory of a case previously seen, a public ward patient, in which right hydrothorax, hydroperitoneum, and edema of the trunk in association with enlarged glands in the neck proved at autopsy to be due to Hodgkin's disease with infiltration of the tissue about the vena cava.*

• Rational Elaboration of "Hodgkin's Disease" Idea.—

- a. Lymph glandular enlargement.
- b. Fever.
- c. Enlargement of liver and spleen.
- d. Involvement of mediastinum.
- e. Infiltration of tissue about vena cava.
- f. Diphtheroid bacillus.
- g. Papular exanthem.
- h. Blood picture.
- i. Histology of lymph gland.

Corroboration of the Inference.—There is identity between the facts collected and the elaborated diagnostic suggestion. A lymph gland was excised and was studied histologically. In the histologic section, stained with hematoxylin and eosin, the typical "Dorothy Reed lesions" of Hodgkin's disease were visible.

Diagnosis.—

1. Hodgkin's disease (lymphadenitis; anemia; venous obstruction).
2. Oral sepsis.
3. Undernutrition.

6. What Are the Relative Values of the Different Parts of the Diagnostic Examination?

In going over a series of the Massachusetts General Hospital Case Records I find that—

*Canon of agreement.

1. The anamnesis was always recorded and always discussed (in arriving at a diagnosis).

2. The physical examination was always recorded whether positive or negative and always discussed.

3. Laboratory examinations:

Urine always recorded, discussed in 25 per cent of cases.

Blood (Hb., R.B.C., and W.B.C.) always recorded, discussed in 30 per cent of cases.

Blood chemistry always recorded, discussed in 10 per cent of cases.

Other laboratory data recorded in 60 per cent of cases, discussed in 90 per cent of cases (high percentage of discussion as compared with urine, blood, and blood chemistry because these examinations were made only when indicated).

4. X-ray study recorded always, discussed in 90 per cent of cases.

5. Electrocardiograph and special examinations recorded in 15 per cent of cases, discussed half of the times recorded.

In reviewing a series of my own cases I *estimated* relative values thus:

	HISTORY (%)	PHYSICAL EXAM. (%)	LABORATORY EXAM. (%)	X RAY STUDY (%)	MISCELLANEOUS (%)
Digestive diseases	75	5	5	15	-
Circulatory diseases	12	65	3	5	15
Respiratory diseases	20	30	10	40	-
Nutrition	25	5	45	5	20
Fever	20	20	50	10	-
Nervous diseases	30	50	10	5	5

These are only estimates; but they estimate two things scientifically: the relative value of a given procedure in any given case, and the number of cases in which a given procedure is of paramount importance. For instance, in a specific case of digestive disorder the history gives one 75 per cent of the information that proves valuable; and in a series of digestive disorders, in 75 per cent of them I find that the history is the feature of primary positive diagnostic importance.

Your estimates may not agree with mine, but it is good mental discipline to make your own estimates.

Example: I select one of the case records of the Massachusetts General Hospital (New England J. Med. 221: No. 17, Oct. 6, 1939). Compare it with Dr. Barker's case as given on page 63 for method. Note the relative amount of space in the record devoted to history, physical examination, laboratory examinations, etc., and note especially the relative amount of space devoted in the discussion to the same divisions.

In the preparation of this section my indebtedness to Dr. Errett C. Albritton, Professor of Physiology in George Washington School of Medicine, is evident to anyone acquainted with his "Physiological Techniques: with standard values and judgment of evidence." In many long passages I have practically quoted him verbatim, but omitted quotation marks in order to avoid interruption of the reader's train of thought. For this I have Dr. Albritton's kind permission and extend my gratitude to him.

CASE 25431

Presentation of Case

Part I.—History.

(Note the space devoted to the patient's recital of the symptoms.)

A 39-year-old Russian-born Jewess was admitted to the hospital complaining of pains and swelling in the extremities and of cough.

The patient stated that she had always been well and active until eight months before admission when, while working as a clerk in a department store, she was suddenly seized with a constant, nonradiating sharp pain in the calf of the right leg while standing. She continued to work for the remainder of the day. She returned home and went to bed, where she remained for five to seven weeks under the care of a physician. The latter stated that the leg was swollen from ankle to knee and that it was tender, especially along the course of the superficial veins, which felt "hard, like cords." She improved slowly and six months before entry returned to work. Ten days later, however, a severe sharp pain was noted in the right chest, which was made worse by breathing. She again went to bed for three or four days when she developed a hacking cough productive of about a fourth of a cupful of thick, yellowish, nonfoul-smelling, occasionally blood-flecked sputum. This cough and chest pain persisted for about three months, but three weeks later the tissues and lymph nodes in the right half of the anterior neck became swollen and markedly tender. The neck veins became enlarged, dark blue, firm and "cordlike," but disappeared in three weeks. The right arm and left leg became similarly involved, so that they were swollen, tender, and faintly cyanotic, and the palpable veins "cordlike." These symptoms slowly subsided until six weeks before admission, when the patient, still ailed, noted an increase in the severity of her cough so that she had paroxysms, with the raising of foul-smelling, heavy, yellow, rarely blood-flecked sputum, which nauseated her and occasionally caused her to vomit. Furthermore, she stated that the right chest pain which she had previously experienced was stabbing, aggravated by cough, and located in the right infra-clavicular region. She said that x-ray films taken in an outside hospital six weeks before entry showed findings interpreted as being "infarct." Two weeks before admission the patient thought that the ends of her fingers had become larger. During the present illness she was reported to have gained 16 pounds in weight. At no time had she experienced night sweats or fever. The patient further stated that she had had mild previously asymptomatic varicose veins for several years.

Her family history was noncontributory.

Part II.—Physical examination.

(Negative findings were largely omitted.)

Physical examination revealed a light, obese, tanned woman who was coughing up blood-stained sputum at frequent intervals. There were a few, almost healed psoriatic lesions over the right ankle and forearm. The right pupil was larger than the left. The throat was slightly injected. In both supraclavicular regions and in the left posterior triangle, were numerous tender nodules 0.3 to 2.0 cm. in diameter. The suprasternal dullness was slightly widened. Examination of the heart was negative. Examination of the lungs showed questionable amphoric breathing over the region of the right middle lobe. There was a moderate degree of

clubbing of the fingers. The veins of the volar surface of the left forearm were tender and apparently thrombosed. There were very mild varicosities of the legs. There was no residual brawny swelling anywhere. A rectal examination showed only small internal thrombosed hemorrhoids. Nothing abnormal was felt in the pelvis. The introitus was vaginal.

The temperature was 99° F., the pulse 88, and the respiration 24.

Part III. Laboratory examinations.

Examination of the urine on many occasions was essentially negative. The blood showed a red cell count averaging 4,700,000 with 70 per cent hemoglobin, and a white cell count which averaged 25,000 with 85 per cent polymorphonuclears. The stools were guaiac negative. Sputum culture showed a heavy, practically pure growth of monilia. A blood culture and Weil-Felix and undulant fever agglutination tests were negative. A blood Hinton test was negative. The electrocardiogram showed a ventricular rate of 75, with normal rhythm, upright T1 and T2 with flat T3 and a tendency to low voltage. X-ray films of the chest revealed scattered areas of consolidation throughout both lung fields, which were confluent in both middle lung fields, particularly in the right middle lobe and in the anterior portion of the right lower lobe. In the left lung field there were multiple, round, poorly defined areas of increased density. Films of the hands showed slight soft-tissue swelling about the terminal phalanges, but the bones showed no evidence of osteoarthropathy. A gastrointestinal series was negative.

Part IV. Course of the disease under observation.

On the day after admission the temperature rose to 100.5° F., and remained at about this level throughout her stay. On the eleventh hospital day, after leading an uneventful hospital course, she developed thromboses of two superficial vessels in the calf of the right leg, which were biopsied. Anaerobic and aerobic cultures were negative; the small vessels removed showed acute thrombophlebitis. Subsequently, at varying intervals smaller lesions appeared on the wrists, arms, and thighs. The patient slowly but steadily became weaker, and despite digitalization her edema persisted. Additional x-ray films of the chest showed no significant changes from those previously observed. One month after entry the patient suffered from two attacks of epistaxis. Examination revealed a bleeding point in the left nare, which was controlled by cauterization and packing. On the fiftieth hospital day she suddenly developed massive edema of the left arm and became markedly dyspneic. Edema of the legs increased in amount, and she died on the fifty-third hospital day.

Differential Diagnosis

Dr. Walter Bauer: "The small vessels removed showed acute thrombophlebitis." Was that a real thrombophlebitis?

Dr. Tracy B. Mallory: It might be fairer to say "acute thrombosis"—a fresh thrombus with no inflammatory reaction whatever.

Dr. Bauer: A real thrombosis? ..

Dr. Mallory: Yes.

(Note the proportionate space given by the diagnostician to the discussion of history, physical findings, and special findings.)

Discussion of history.

Dr. Bauer: I do not believe there can be much doubt that this woman fell ill eight months prior to admission. The question is, Was the initial illness related to what was subsequently found in her chest? I think there can be little doubt that she was suffering from migratory phlebitis or phlebitis migrans. The story is quite characteristic of this disease syndrome. Whether migratory phlebitis is a distinct disease entity, no one really knows. It is a relatively rare condition. I suppose it is more frequently encountered in thromboangiitis obliterans than in any other disease. It may be the first symptom of thromboangiitis obliterans. Involvement of the superficial veins is quite characteristic. It begins peripherally, disappearing in one area only to reappear at another a little closer to the heart.

Analysis of history:

This patient was a woman. We know that thromboangiitis obliterans is a relatively rare disease in women. We have no other symptom suggesting its existence in this patient. With the premise of migratory phlebitis followed by a sudden attack of pain in the right chest one might reasonably conclude that this patient had what was diagnosed on the outside by a roentgenologist—a pulmonary infarct. However, I believe pulmonary infarction is rarely encountered in phlebitis migrans. This is due to the fact that the process starts externally and as a rule involves the external and middle coats of the vein. Complete resolution usually occurs in one portion of the vein only to have the process begin elsewhere. Pulmonary infarction is so infrequent that those working in the Peripheral Vascular Clinic do not advocate ligation of the vein in order to prevent pulmonary infarction. I think there are exceptions to this rule. Dr. Mallory can set me straight on this.

Dr. Mallory: My experience is limited, but the cases other than Buerger's disease on which I have seen a biopsy have shown thrombosis regularly, inflammatory reaction in the vessel walls rarely.

Canons of agreement and difference.

Dr. Bauer: The literature on this disease is very meager. The only place I looked it up was in Homans' textbook. Therein it states that in migratory phlebitis one rarely needs to worry regarding the possibility of pulmonary infarction because it occurs so rarely. This is due to the fact that the pathologic process proceeds from without inward.

Dr. Mallory: I think Dr. Homans believes that thrombosis can occur and spontaneously resolve very rapidly.

Dr. Bauer: That is obvious from the course of the disease. It may involve a vein in the region of the wrist or ankle with obvious signs and symptoms persisting for several weeks only to disappear completely. Later the same process may occur in the region of the elbow and subsequently higher up the arm. I think we have to be very cautious in interpreting these chest x ray films. Ordinarily we should say that sudden pain in the chest occurring in a patient with phlebitis means pulmonary infarction. Infarction with infected emboli should cause tissue necrosis, cough, and foul-smelling sputum. We are unable to state just what the situation was in this case. It is of interest that there was a two months' interval between the onset of the first venous thrombosis and

the appearance of sudden severe pain in the chest. At this time there was no evidence of phlebitis. To have a pulmonary embolus at this late date would be unusual. The fact that this patient had no fever is another reason for wondering if the pleural pain was not due to some cause other than pulmonary infarction. This pain persisted from the very onset. You might argue that she had had an infected pulmonary infarct with subsequent abscess formation, lasting three and a half months. This would be unusual in the absence of fever. The fact that her temperature was only 99° F. on entrance is significant. The sputum which she raised was always blood streaked. This is rather unusual, is it not, Dr. King, in the case of pulmonary abscess or an infected pulmonary infarct?

Dr. Donald S. King: Yes.

Discussion of
laboratory data.

Dr. Bauer: This bit of evidence is helpful. She did have a leucocytosis running around 25,000. She developed enlarged supraclavicular lymph nodes. One might argue that they were part and parcel of the phlebitis. However, they persisted despite the fact that the phlebitis disappeared. I wish the description of these lymph nodes was more detailed. They were tender. Were they firm or hard? I should be inclined to believe that this woman was suffering from a migratory phlebitis but that in addition she had cancer of the lung. We shall have Dr. Hampton discuss the x ray films in greater detail a little later. I should be inclined to believe she probably had metastatic carcinoma of the lung rather than a primary tumor. If she was suffering from metastatic carcinoma, where was the primary tumor? I believe that the supraclavicular nodes were "sentinel nodes." I may be wrong, because it is possible for inflamed lymph nodes to persist that long. The continued blood streaking and absence of fever would fit pulmonary cancer better than pulmonary disease in consequence of repeated pulmonary infarction, regardless of whether or not the emboli were infected. These metastatic lesions were bilateral. They may have been secondary to carcinoma of the breast or hypernephroma. Dr. Hampton, can the metastases of hypernephroma be relatively diffuse?

Dr. Audrey O. Hampton: They could be similar to those in this case.

Dr. Bauer: We know she had some red blood cells in the urine. If I were to guess, I should say that her primary lesion was a hypernephroma and that she had metastases to the lungs. I think it is highly probable that this woman's death was due to a pulmonary infarct. I do not believe that repeated pulmonary infarction alone explains the entire situation. I shall say what I think before Dr. Hampton discusses the x ray films. If I have reason to change my mind later I hope that I shall be allowed to do so.

I shall summarize by saying that this patient had a hypernephroma with bilateral metastases to the lungs, and migratory phlebitis. She probably died because of a pulmonary embolus. I doubt if she had the generalized form of pulmonary osteoarthropathy, for no generalized bone pain was present; she did, however, have the localized form.

Laboratory findings.
Rejection of them
as of primary
importance.

Dr. F. Dennette Adams: Do you attach any significance to the report of monilia in the sputum?

Dr. Bauer: I am happier leaving that finding alone rather than trying to attach any significance to it.

Dr. King: On the wards the therapeutic attack was on the basis of the infection with monilia and large amounts of iodide were given.

Dr. Bauer: That is all right by me, but I should prefer to leave the monilia alone because I think it is a red herring. I may be wrong, because I do not know anything about yeast infections of the lung.

Discussion of x-ray.

Dr. Hampton: I am sure this chest picture changed in the time between the outside examination and this one. These quite sharply defined round areas in the left lung could not be infarcts. They are due either to metastatic abscesses or to metastatic carcinoma. The shadow that was interpreted as infarct does look somewhat like one, if you believe infarcts are triangular in shape.

Dr. Mallory: How about a septic infarct?

Dr. Hampton: Septic infarcts or metastatic abscesses could produce this picture. This triangular shape appears at the base of the upper lobe—the middle lobe is not involved particularly, no more than any other part of the lung; however, the lesion looks more like one due to collapse of a portion of the upper lobe than to an infarct. I cannot say positively that it is not an infarct, but it is more like collapse. Certainly if it is an infarct it has been there long enough to reduce the lung in size and to become very sharp in all directions and more like a triangle than an infarct should be. Over a period of months we have evidence of increase in size of this area of density, thus indicating a progressive disease without pleural fluid, and in this section of film you see a very definite round mass. I do not know which side this mass occupies, but I assume it is in this area here at the right. She did have swelling of the soft tissues around the terminal phalanges without bone changes.

Canon of agreement.

Dr. Bauer: Could such an x-ray picture be secondary to a primary cancer of the lung?

Dr. Hampton: Yes.

Dr. Bauer: Would you be inclined to think that this lesion here, plus the other findings, was consistent with carcinoma?

Canon of difference.

Dr. Hampton: I could not explain the triangle on the basis of cancer, but I could account for the round mass on the basis of metastasis.

Dr. Bauer: Is it fair to ask Dr. Hampton to make a diagnosis?

Dr. Mallory: Yes, at this stage.

Dr. Bauer: I do not believe I shall change mine.

Dr. Hampton: I should explain the small focus at the base of the right upper lobe as being due to a primary tumor. It could, however, be due to metastatic infection or to metastatic malignancy.

Dr. Bauer: Let us leave for a moment the question as to whether it is primary in the lung or elsewhere. If we make a diagnosis of malignancy are you willing to make in addition a diagnosis of pulmonary infarction?

Dr. Hampton: No.

Dr. Bauer: What would be the easiest way to explain the exitus?

Dr. Hampton: That triangular lesion could be an infarct. We did not have a film taken after death, which would show the infarct if it happened at that time.

Dr. Bauer: I shall leave it that way. I was not able to interpret whether this was primary carcinoma of the lung or the result of metastases.

Dr. Mallory: There is one other piece of information which was withheld. I do not believe it would have helped you much. One of the lymph nodes in the neck was biopsied and showed an unclassified malignant tumor, probably a carcinoma.

Dr. King: What do you think about the recurrent hemoptysis in relation to whether it was primary or metastatic cancer of the lungs?

Dr. Bauer: It would fit primary carcinoma of the lung much better. If I had given that more thought, even though I did not have the expert interpretation of the x ray films, I should have come nearer to making what I now believe is the right diagnosis, namely primary carcinoma of the lung.

Canon of agreement.

Dr. J. H. Means: I should like to speak on one point. I did not have this patient in charge but saw her once on teaching rounds. I agree entirely with Dr. Bauer's thought that she had a migratory phlebitis. He raised the question whether embolism would occur in this disease. I shall merely cite a patient of mine who I think had the same disease. He did have a series of pulmonary emboli with infarcts but without any infection, as in this case. These cleared up rapidly. After his tonsils had been removed and his epidermophytosis had cleared up, he recovered. Whether that had any relation to the migratory phlebitis, I do not know; but Dr. Arthur W. Allen, who saw him in consultation, expressed the belief that a fungus infection might play a role in the etiology of migratory phlebitis. I mention the case because of the embolism. I am sure it may occur.

Dr. Bauer: Yes, but as I have said it is so rare that ligation is not indicated.

There is one other point about thromboangiitis obliterans. At the Mayo Clinic they have tried to prove that it is an infectious disease. The evidence thus far is not very convincing.

Clinical Diagnosis

Carcinomatosis.
Phlebitis migrans.

Dr. Bauer's Diagnoses

Carcinoma of the lungs († primary † metastatic), with widespread pulmonary metastases.
Phlebitis migrans.
Pulmonary infarct.
Pulmonary osteoarthropathy.

Anatomical Diagnosis

Primary carcinoma of the lung, right middle lobe, with extension and metastases to opposite lung, mediastinum, pericardium, pleura, and lymph nodes.

Thrombophlebitis of femoral and common iliac veins and inferior vena cava.

Hydrothorax.

Hydropericardium.

Leiomyomas of the uterus.

Atherosclerosis of the aorta and coronaries, minimal.

Pathological Discussion

Deduction following induction.

Dr. Mallory: So far as the migratory phlebitis of Buerger's disease is concerned, in the acute stage it regularly shows a highly specific picture, with multiple miliary lesions made up of monocytes and giant cells that suggest miliary tubercles or gummas. This patient did not show any such picture. I think that is an important point against Buerger's disease as the cause of the phlebitis in this case.

The autopsy showed that the primary lesion was in the middle lobe of the right lung. It was a nodule of cancer about 5 cm. in diameter, surrounding and growing into the primary bronchus of the right middle lobe. There were multiple metastases throughout both lungs, the result of extension through both the lymphatics and the blood stream. Metastasis had occurred to other parts of the body. Many of the retroperitoneal nodes were involved, as well as those that you have heard about in the neck. The phlebitis was very extensive and involved a great many large veins as well as small ones. In fact both femorals, both iliacs and the inferior vena cava itself for a distance of 8 cm. were filled with thrombus. Why an embolus had not broken off I cannot imagine, but there was not a single infarct in the lungs.

Dr. Bauer: You have not explained the sudden exitus.

Dr. Mallory: No. A possible thing was that she had a carcinomatous pericarditis with a significant amount of fluid—300 c.c.

Dr. Bauer: Cardiac tamponade?

Dr. Mallory: Perhaps. Three hundred cubic centimeters of fluid would not produce tamponade in a normal pericardial sac but with the walls stiffened and rendered inelastic by cancer it might.

Dr. Bauer: I should think the mistake I made was in not interpreting the continuous blood streaking correctly. I should have realized that that would be rather unusual with metastatic carcinoma.

Dr. King: We have seen a few cases, about three or four, where hemoptysis has occurred with metastatic malignancy.

Dr. Hampton: That discussion came up some time ago. We looked it up after a fashion, and as we reviewed the cases that were treated in the Tumor Clinic, we found that metastatic carcinoma very rarely produces hemoptysis.

Dr. Bauer: That is very significant. If I had interpreted it properly, I should have made the correct diagnosis the first time. Such points are extremely important to remember.

7. Chances of Success in Diagnosis.—What are the possibilities of failure and success? Not to have made mistakes and humiliating mistakes in diagnosis is simply not to have had any experience. But how hopeless is the quest? Or how hopeful? Well, statistics are solid ground and we have some statistics.

In 1910, and in an expanded article in 1912, the late Dr. Richard C. Cabot, of Boston, reviewed the mistakes made in diagnosis at the Massachusetts Gen-

eral Hospital. (Cabot: A Study of Mistaken Diagnoses, *J. A. M. A.* 55: No. 16, Oct. 15, 1910. Ibid: Diagnostic Pitfalls Identified During a Study of Three Thousand Autopsies, *J. A. M. A.* 59: Dec. 28, 1912. Ibid: Common Diagnostic Errors, *J. M. Soc. New Jersey*, 1912.) This was based upon the clinical record and the clinical diagnosis compared to autopsy findings. He listed the percentages of diagnostic success in twenty-eight common diseases as follows:

	PER CENT
Diabetes mellitus	95
Typhoid fever	92
Aortic regurgitation	84
Cancer of the colon	74
Lobar pneumonia	74
Chronic glomerulonephritis	74
Cerebral tumor	72.8
Tuberculous meningitis	72
Gastric cancer	72
Mitral stenosis	69
Brain hemorrhage	67
Septic meningitis	64
Aortic stenosis	61
Phthisis, active	59
Miliary tuberculosis	52
Chronic interstitial nephritis	50
Thoracic aneurysm	50
Hepatic cirrhosis	39
Acute endocarditis	39
Peptic ulcer	36
Suppurative nephritis	35
Renal tuberculosis	33.3
Bronchopneumonia	33
Vertebral tuberculosis	23
Chronic myocarditis	22
Hepatic abscess	20
Acute pericarditis	20
Acute nephritis	16

Dr. Cabot did not furnish the total percentage of error in all of his cases.

In 1919 Karsner, Rothschild and Crump (*Clinical Diagnosis as Compared With Necropsy Findings*, *J. A. M. A.* 73: No. 9, Aug. 30, 1919) published a similar report on the basis of 600 cases. In fifty of these cases, or 8 per cent, there were "gross errors" in which the lesion did not involve even the same organ or system mentioned in the clinical diagnosis. There was a 60 per cent factor of minor error classified as follows:

ORGAN OR SYSTEM INVOLVED	CORRECT DIAGNOSIS (%)
Head and brain	60
Heart and pericardium	52
Lungs and pleura	54
Liver and biliary tract	57
Gastrointestinal tract	54
Nonsuppurative nephropathy	60
Blood vessels	24

Some resentment was expressed at Dr. Cabot's statements in certain quarters at the time of the publication of his paper, but largely American diagnosticians took his wholesome lesson very humbly to heart and tried to improve their methods. In the meantime great advances in technical procedure had occurred. When Dr. Cabot read his paper, the x-ray was hardly out of its swaddling clothes; blood chemistry, the electrocardiograph, and other procedures were not a routine part of the clinical examination.

Is it possible, then, that today's diagnostic success has risen since 1912? And over Karsner, Rothschild and Crump's results of 1919? For a number of years the *New England Journal of Medicine* has been publishing the record of the weekly clinicopathological conference at the Massachusetts General Hospital. These conferences were founded by Dr. Cabot and carry out his method of requiring the clinician to commit himself to a diagnosis; then the autopsy or operative record is compared to the clinical diagnosis. The clinician's discussion is recorded in full (for example case see page 67): a secondary or even three or four secondary diagnoses are listed—for instance, bronchopneumonia and thrombophlebitis complicating the primary lesion.

I have analyzed two hundred of these cases consecutively to determine the percentage of diagnostic successes and failures, with these results:

	PER CENT
Complete agreement on primary diagnosis	80
Complete disagreement on primary diagnosis	15
Complete agreement on secondary diagnosis	90
The correct diagnosis as proved by autopsy or operation considered by the diagnostician and rejected during the course of his discussion	12
Practical agreement on primary diagnosis	3
Primary diagnosis listed as secondary	2

Typical mistakes were:

CLINICAL DIAGNOSIS	AUTOPSY DIAGNOSIS
Carcinoma of the ovary with peritoneal carcinoma	Carcinoma of the stomach with peritoneal carcinoma
Cirrhosis of the liver	Carcinoma of the gall bladder
Carcinoid	Tuberculosis of the intestines
Lymphoma of the stomach	Meckel's diverticulum with obstruction

This is a remarkable record. The cases selected for presentation are tough cases—the toughest of the tough. That 80 per cent of complete success should be attained, and that even in failures, in four-fifths of the instances the correct diagnosis was considered as a possibility and rejected for lack of suitable evidence, divides this experience by a chasm from the experience of 1910. The result, as I noted above, is partly due to technical improvement, but largely due, I think, to the influence of Dr. Cabot's insistence on complete intellectual honesty and exhaustive review of all the possibilities.

In simpler cases—paralysis agitans, exophthalmic goiter, heart failure, leucemia, rheumatoid arthritis, tabes, etc.—the percentage of diagnostic success should be 100 per cent. The acute contagious diseases, while often presenting puzzling features, should yield over 95 per cent of successes.

So we may say to the prospective candidate for the title of diagnostician that he can, with perseverance, attain success in his objectives in quite a high proportion of cases.

References on Diagnosis

Literature on the technical aspects of diagnosis—physical diagnosis, laboratory, x ray, instrumental diagnosis—are plentiful, but works on the fundamental reflective, reasoning processes and fallacies encountered in diagnosis are all too few. I have found the following valuable:

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Mostly case histories, grouped on the basis of a symptom or sign. In spite of its date a constant source of inspiration.
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Printed every week in the *New England Medical Journal*. Recommended for faithful weekly perusal.

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THE HISTORY

—Kipling

DATE _____

OCCUPATION

BIRTHPLACE

Final Diagnosis

- 77

This history outline, or one like it, should be an integral part of any clinician's mental equipment. He should follow his history routine slavishly: when he grows so old or confident or careless that he relaxes this observance, he begins to make mistakes.

The history is the balance wheel of the diagnosis. It focuses attention on the main problem. If the laboratory data, no matter how voluminous, disagree with the history, the laboratory data are either wrong or not pertinent.

Although subject to certain inherent errors due to the vagaries and the unreliability of the witness, who is the patient—the uncertainty of his memory, his unfamiliarity with the material—taking them by and large, histories are remarkably dependable.

In order to evaluate the history, the clinician must interpret the symptoms. This involves first, a knowledge of the pathologic physiology which produces them. Unfortunately our knowledge here is often deficient. For instance, pain is a universal human experience. Yet a cursory review of the paragraphs below will show you that our insight into the physiologic changes that result in pain is negligible.

Secondly, the clinician must know the diseases, organic or functional, which are associated with any symptom. What diseases cause the *presenting* symptom? Here our knowledge is much more complete and more practical.

Below we will discuss a number of the commonest symptoms.

First we take the “pure” symptoms—the sensations that the patient alone feels and which the clinician has no way of checking by physical signs. Pain is the best example.

Pain, anesthesia, fatigue, hunger, thirst, anorexia, and nausea are the only pure symptoms. The physician, when he meets one of them, must be able to run over in his mind what diseases could be the cause of this symptom.

Then we take up the symptoms that are both symptom and sign. For instance, dyspnea. The patient experiences air hunger, and the physician can see it in the rapid and labored breathing.

I. PAIN

The commonest symptom which brings a patient to call for medical aid is pain; about the ultimate nature and physiology of pain we know next to nothing.

The real difficulty in the clinical investigation of pain is that, since it is a personal judgment of the patient, we are compelled to allow for the infinite differences in personal response; some persons are honestly more and some honestly less sensitive to pain than others. Add to this the qualities of hysteria and malingering and experience is indeed fallacious and judgment difficult.

A further technical difficulty in the investigation of pain is that man is the only animal that can be used for experimental purposes. So it is surprising rather than otherwise that we know as much as we do.

The investigations of Head and Rivers (Brain, 1905 and 1908) on cutaneous sensibility, including pain, established that in the skin there are definite nerve endings and fibers that carry the sensation of pain, while others carry ordinary sensations of touch, others cold, and others warm sensations. Pain then, at least in the skin, is not simply an overstimulation of sensory fibers, but has its own receptors and pathways.

When a skin area is made anesthetic by section of the nerve supply, there remains a deep subcutaneous sensibility to pressure and movements, which must be mediated through sensory fibers in the muscles, fascia, etc.

When, after section, a cutaneous nerve begins to regenerate, the sensations return in different orders. Pain and temperature sense return first, but the sensations are imperfectly localized or, in other words, the threshold is high. This kind of sensation is found in the viscera also. This was called by Head and Rivers protopathic sensibility—pain, cold (not stimulated above 26° C.), heat (not stimulated below 37° C.). The second system of fibers responds to stimulation by light pressure and small differences in temperature. They regenerate more slowly. The sensations mediated by them are localized very exactly and for that reason were called *epicritic*.

These considerations apply to the skin and mucous membranes (cornea and buccal mucosa). Various areas differ in sensibility to pain—the finger tips more than the rest of the skin, the cornea more than the finger tips. Histologic examination of the pain points shows that there is no especial end organ that can be distinguished anatomically for pain, and any form of nerve stimuli, heat, cold or pressure, if extreme, will arouse the pain sense.

Other structures are sensitive to pain in varying ways. Subcutaneous fat has little pain response. Fascia, tendons, and periosteum are quite sensitive. Muscles are not sensitive to cutting or pricking, but very sensitive to ischemia, injection (as of a salt solution), or pinching. Compact bone is not sensitive but cancellous bone is. The articular surfaces of joint structures are insensitive but the synovial lining of ligamentous structures is very sensitive to scratching and to hypertonic saline. Arteries and veins are insensitive to needle pricks, but crushing of arteries is sometimes productive of pain, and embolism, as is known clinically, gives rise to excruciating pain (though this probably may be due to the resultant muscular ischemia).

The viscera in general are curiously insensitive to cutting, crushing, and burning. The experiments of Lennander and others on the abdominal viscera and of Capps on the pleura and pericardium are recorded elsewhere (see p. 382).

The parietal peritoneum is sensitive to pain stimuli, especially to tension. Mackenzie stated that he could scratch it without pain, but Morely denies this; at least over the dome of the diaphragm he found it very sensitive. All experiments agree that passing a surgical sponge over the parietal peritoneum results in severe pain.

The omentum is insensitive.

The mesenteries are insensitive to direct stimuli, but traction on them results in pain.

The rectum is insensitive to pain stimuli, but the anal canal is very sensitive.

Distention of the pelvis of the kidney produces pain.

The fundus of the bladder is insensitive, but the base is sensitive to pain.

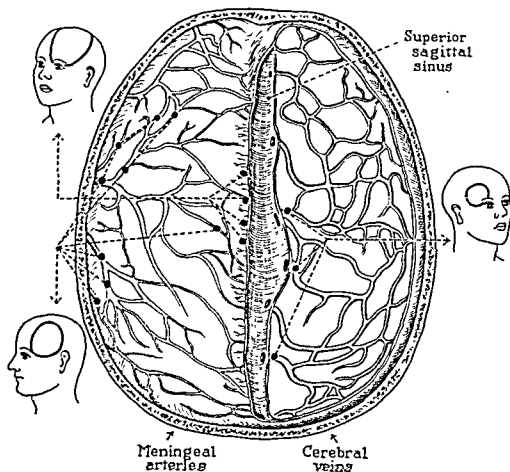


Fig. 1.—Calvarium removed. Surface of the dura and meningeal arteries is shown; points where stimulation caused pain and areas of localization of the pain. Note that stimulation over arteries themselves caused pain, a confirmation of the congestion explanation of throbbing headache. (After Hay and Wolff: *Arch. Surg.* 41: 813, 1910.)

The testis is insensitive to pain, according to Lennander, but its scrotal coverings are sensitive. Mackenzie tested the tunica vaginalis and proclaimed it to be the only sensitive serous membrane he had ever encountered.

The uterus can be cut or burnt, the broad ligaments dissected painlessly. The cervix, as is well known, can be grasped by tenaculum and drag made without pain. The ordinary experiences of pregnancy and labor teach us that distention of the uterus is painless, although contractions bring pain.

The vagina is said to be insensitive to pain beyond a centimeter or more from the orifice. Lennander found the vaginal wall to be insensitive to cautery, faradic current, incision, and clamping. The fornices are, however, believed to be sensitive.

The urethra is very sensitive at its mouth. It, of course, is sensitive throughout to distention, but no tests for ordinary sensitivity of its walls have been made that did not involve stretching.

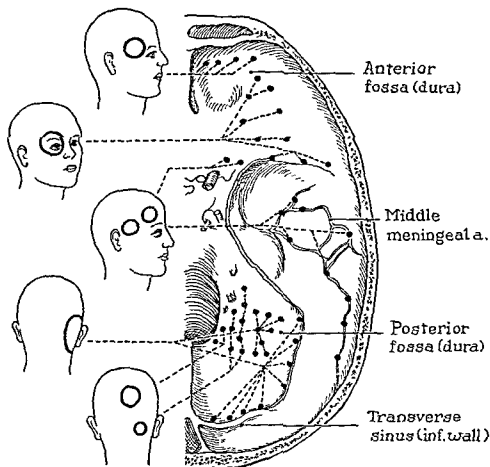


FIG. 2.—Dural floor of skull, showing points where stimulation caused pain and indicating the area of localization of the pain. (After Ray and Wolff: *Arch. Surg.* 41: 813, 1940.)

The brain is insensitive over its entire surface, according to most observers. Cushing (*Brain* 32: 44, 1909) could elicit no pain by faradizing the cortex in the region of the Rolandic fissure. Foerster reported paresthesia from faradizing the postcentral and superior parietal gyri. He believed pain had some cortical representation.

The dura is insensitive to incision, scratch, cautery, and electric stimulation. But in the region of the large vessels and sinuses this is not true. Cushing believed the falx and tentorium to be sensitive.

Ray and Wolff (*Experimental Studies on Headache: Pain-sensitive Structures of the Head and Their Significance in Headache*, *Arch. Surg.* 41: 813,

October, 1940) made complete and careful experiments on thirty patients, testing out the pain sense of every part of the structures of the head from the skin of the scalp to the basal dura. Their results are extremely valuable; the original paper should be consulted by everyone interested.

In general the gist of their findings is that pain in the head is located in the blood vessels. Dural pain points correspond to the locale of arteries and veins of some size. (The basal dura, however, is pain-sensitive at a few points separate from vessels.)

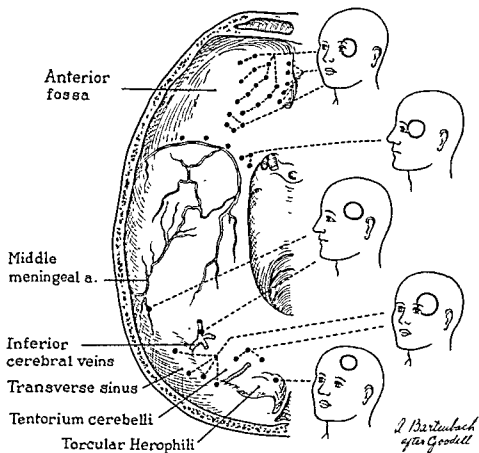


Fig. 3.—Dural floor of the skull, showing points where stimulation caused pain and areas of localization of pain when corresponding points were stimulated. (After Ray and Wolff; Arch. Surg. 41: 813, 1940)

The distention of cerebral arteries is primarily responsible for the headache produced by certain pharmacologic agents, such as histamine, and the headache produced by septicemia and infection belongs in the same category.

They conclude, in part:

"1. Of the tissues covering the cranium, all are more or less sensitive to pain, the arteries being especially so.

"2. Of the intracranial structures, the great venous sinuses and their venous tributaries from the surface of the brain, parts of the dura at the base,

the dural arteries and the cerebral arteries at the base of the brain are sensitive to pain.

"3. The cranium (especially the diploic and emissary veins) the parenchyma of the brain, most of the dura, most of the pia arachnoid, the ependymal lining of the ventricles and the choroid plexuses, are not sensitive to pain."

"From the data available six basic mechanisms of headache have been formulated. Headache may result from (1) traction on the veins that pass to the venous sinuses from the surface of the brain and displacement of the great venous sinuses; (2) traction on the middle meningeal arteries; (3) traction on the large arteries at the base of the brain and their main branches; (4) distention and dilatation of intracranial and extracranial arteries; (5) inflammation in or about any of the pain-sensitive structures of the head and (6) direct pressure by tumors on the cranial and cervical nerves containing many pain-afferent fibers from the head."

They present many diagrams showing the localization of headache, depending upon what structure is stimulated. But since any given headache is caused by several mechanisms and is likely to be the result of multiple stimulations and since the localization is seldom precise, diagnostic conclusions from such mapping should be accepted with caution.

The influence of position, time of day, activity, etc., on pain has, at times, some diagnostic value.

More important than all in evaluating pain is to assess the personality of the patient. Long ago a writer in the *Lancet* well said:

"Pain is in inverse proportion to the vividness of the description, or to the square root of the adjectives, or directly proportional to its boringness. Unfortunately another element of receptivity comes in, the listener's, for some people are more easily impressed or bored than others, and vary at different times of the day."

Sensitiveness to pain notoriously varies with different individuals. Libman (*J. A. M. A.* 102: No. 5, Feb. 3, 1934) has suggested a test to determine whether a patient under study is or is not hypersensitive "by pressing the thumb against the tip of the mastoid bone and then slipping the finger forward and pushing against the styloid process. Pressure on the normal mastoid causes no pain and therefore serves as a control. It is important not to rub the bone because rubbing the periosteum of any bone is likely to evoke pain. Pressure in the direction of the styloid is painful to some individuals and not to others. The sensitive point is really not the styloid process, but a branch of the auricularis magnus nerve."

A. Pain in the Head: Headache

Innumerable conditions produce headache of acute onset and duration—reflex, toxic, and infectious. Nearly any general infection begins with a headache; also fatigue, postalcoholic states, internal hemorrhage, constipation, overexposure to sun and wind, allergic states—come in this category. Localization of the ache is not of much diagnostic value.

Chronic headache is also caused by many conditions, but in a study of a consecutive series of clinic patients made several years ago I found that the great majority of chronic headaches were due to migraine, neurosis, or eyestrain

1. **Migraine** is one of the great medical diseases, a common cause of chronic invalidism. Yet there are few common diseases so often misdiagnosed, or which go entirely undiagnosed, as this. Many of its victims go through life, and see a hundred doctors, without getting a diagnosis; they suffer outrageous mismanagement; they have teeth out, sinus operations, "deviated" septa undeviated, glasses endlessly changed, all manner of gynecologic atrocities, gastroenterologic clowning, psychoanalysis—all of which they could have been saved if someone had explained the condition to them in the beginning.

The manifestations of migraine are so protean, it presents under so many guises, it has been the subject of so many clinical explanations, that not a few physicians have denied its existence. But this, I am sure, is an error. Although it is entirely functional, with no discoverable anatomic basis, it is none the less real. It is somatic and not psychic. It is not even psychosomatic.

"Sick headache," the common name for it, is acceptable. It has a digestive part (sick—i.e. nausea, vomiting) and a cephalic part (headache): they are usually conjoined, but may exist separately.

Many explanations of the mechanism of migraine have been advanced, but none is satisfactory. Several are dangerous, notably that it is a reflex, because this leads to polysurgery. If it is allergic, it is not like any other allergy known. My experience is all against the idea that the neurotic members of a family tend to inherit it: most of the victims I have known have been notably well-balanced and stable. The most suggestive explanation is that it is due to spasm of the cerebral arteries: in many instances the temporal arteries are felt to be small and the retinal arteries on the affected side have often been observed to be in spasm. Transient hemiplegia has been reported. The beneficial action of ergotamine tartrate, which functions by dilating the arteries, has been used as an argument in favor of this theory (Graham and Wolff: *Arch. Neurol. and Psychiat.* 39: 737, 1938). At the height of the attack spasm gives way to dilatation, the temporal arteries throb, and one side of the head feels warmer than the other.

The fact that it is definitely hereditary does not explain the mechanism, but it is a helpful diagnostic point. Allan (*Arch. Int. Med.* 42: 591, 1928) in a careful study of 500 cases, found that in 56 families in which both parents were migrainous, with 318 children, 240 had migraine, 48 did not, and 30 were too young or could not be traced—a positive figure of 83.3 per cent. In 141 families in which one parent was migrainous, there was a positive figure of inheritance of 61 per cent. In 98 families in which neither parent had migraine, 3.7 per cent of the children had migraine. Kovalsky traced the malady through three generations in 18 out of 110 cases, and Mills once traced it through five generations.

The diagnosis can be made and a given case of headache properly labeled if the clinician will go over the history, carefully eliciting the following characteristics. They will not all be present in any one case, but any combination is suggestive:

(1) **PERIODICITY AND RECURRENCE.**—This is the most significant and constant symptom. Any headache that comes at intervals is migraine until

proved otherwise. It may be called neuralgic headache or more often "my" headache. The patient may have other headaches, but they are not the same; *the enemy in his well-known guise and habiliment is always recognizable*. The periods may be regular or not, long or short. A monthly periodicity is common, but it has no relation to menstruation necessarily. I know one patient with indubitable migraine, who has it every morning. It is gone by noon, and he is greatly relieved by ergotamine.

(2) *UNILATERAL*.—This is extremely variable, more often absent than present, but when present it is a strong and powerful clue. If not definitely unilateral, the patient may acknowledge that it is worse on one side than the other. One pupil may be dilated. The behavior of the temporal arteries is described above. In any one individual one side may be always affected, or the pain may alternate from one side to the other. It is generally worse in the temple, the orbit, and the jaw.

(3) *AURA*.—If careful inquiry be made, by questions based on experience, aura, contrary to many textbook questions, will nearly always be found. The victim nearly always knows, in other words, when an attack is coming. In migraine, in contrast to epilepsy, sensory and motor aura are least common, but *bodily states give the hint*.

Aura of Bodily State—Euphoria.—"I never feel more happy, more energetic and buoyant than on the day preceding an attack and have long ago learned to expect a day of suffering to follow these pleasurable sensations," wrote Dr. Sidney Kuh (J. A. M. A., Feb. 19, 1910), describing his own case. A particularly good and refreshing night's sleep is a signal in others. One patient told me that for hours before an attack he had a sense of great prescience: *common things, such as commercial advertisement signs, took on deep and mystical significance, he saw into the mind of God and knew all the secrets of the universe*. In others the aural state is one of depression: they are cross and irritable. Inability to concentrate on routine tasks is contrasted with a state of demoniac activity—one housewife referred to herself as "Dutch Cleanser" and her husband called her "a fanatic with a dust brush" the day before an attack. (Bing and Haymaker: *Diseases of the Nervous System*, 1939.)

Sensory Aura.—Hallucinations have been described. Immediately preceding the headache one of Wier Mitchell's patients saw a bright cloud and parti-colored rain. "On going upstairs, she was aware of being accompanied by a large, black, and very hairy dog. A severe pain over her left eye and the dog was gone." Another saw her long-dead sister in a mirror. Visions of black cats are repeatedly described.

The ocular light displays, as classically described, in my experience are rare. Some ocular phenomena occur in 57 per cent of cases. *Teichopsia* fortification spectra, zig-zag lines illuminated with gorgeous colors, expanding scotomas are the forms most often described.

Paresthesias, tingling of the fingers, tinnitus, dizziness, chilly feelings, are other forms of sensory aura.

Motor Aura.—Drooping of one eyelid, transient aphasia and transient paralyses, frequency of urination, a feeling of weakness, are among the most frequent motor aura.

(4) **ASSOCIATION WITH DIGESTIVE DISTURBANCE.**—The sick part of sick headache is just as important as the *headache*. In fact, it may exist alone—*abdominal migraine*. Many persons go through life having periodically what they call “bilious attacks” or “my bilious attacks,” which are really migraine. About 40 per cent of migraine patients start off an attack with vomiting and are nauseated for the early part of the attack. An even commoner feeling is that of paralysis of the bowel. “In my own case, at least,” wrote Dr. Sidney Kuh, “there is a very peculiar abdominal sensation which may best be described as a negative sensation, the absence of a sensation normally present, which I am inclined to attribute to the absence of the normal peristaltic movements. At such times my intestinal tract, ordinarily very sensitive to cathartics, fails to react to their administration.” Many victims find that if at the warning or beginning of an attack, they can get a cathartic to act, the attack will be aborted.

Various migraine “equivalents” have been described, such as paroxysmal tachycardia, spells of vertigo, states of mental depression, which take the place of migraine attacks, but the argument seems to me strained. (Slight and Morrison: *Am. J. Psychiat.* 97: No. 3, November, 1940.)

(5) **LIFE HISTORY OF MIGRAINE.**—In a given case of chronic recurrent headache it is of some diagnostic help to learn at what age the attacks started. If one elicits the history that they began at fifteen to twenty years of age, that at first they were comparatively mild and became gradually more severe, and then again eased off in severity, it is a confirmatory point. Eyestrain headaches begin when reading begins, neurotic headaches later when the stress of life presses.

(6) **THE SYMPTOMATOLOGY AND PHYSICAL PHENOMENA** of an attack are not of great diagnostic help because they are so variable. The pain is sometimes described as throbbing, sometimes as constant. Movements, lights, noises make it worse. One side of the face may be warmer than the other. The face is sometimes described as alternately flushed and pale. The pulse is usually regular, blood pressure is unchanged. Ptosis of one eyelid may persist through the attack. Appetite is gone and food is refused. Valliex's tender points of exit of the ophthalmic (supraorbital, nasal, palpebral), trigeminal (infraorbital, malar, dental, auriculotemporal), and occipital (postauricular) nerves are not constant or reliable.

2. Neurotic Headaches.—Neurotic is a poor word but will have to serve. They are not exactly neurasthenic nor hysteric, these headaches, at least according to my definitions. They are, I suppose, escape mechanisms. Many a man has avoided regular employment, many a woman has kept a family dancing attendance by the means of this simple device.

“To use a Hibernianism, the most striking peculiarity of a neurasthenic pain in the head is that it is no pain at all. The patient would probably feel this paradoxical statement to be a personal affront, or would at least term it a

characteristic medical absurdity. Nevertheless, it holds good. However bitterly the victim may complain of his head, however truly and constantly he may suffer, the fact remains that careful inquiry will nearly always show the headache to be not a hurt but a distress or discomfort. Be it at once understood that this does not minimize the affliction, for in the same breath with which the patient acknowledges that it is not exactly a pain, he will earnestly and honestly aver that he would ten times rather have a regular pain. What he has is a sense of pressure or constriction or expansion; a feeling of heaviness, of lightness, of fullness or emptiness; a sensation as of a foreign body within the cranium, or as if there were a *vacuous cavity which needed filling*. The foreign body complained of may appear to be liquid or solid, loose or fixed, and the conviction of its presence be so complete that the patient demands operation for its removal. A frequent complaint is of a feeling that there is some material hindrance to mental effort—an intense appreciation of some obstruction to brain action. Sometimes this is described as a veil, screen, or cloud that darkens and retards all intellectual activity, or the plaint is simply of a dull, deep-seated, frontal, occipital, or temporal *something* which the sufferer is unable to define with nicety. Altogether too frequently one hears about a pressure at (or on) 'the base of the brain,' a glamoring expression which emanated, I regret to say, from the medical profession, and which, notwithstanding its utter absurdity, still lingers in the nomenclature of our submerged fifth.

"In my experience a geometrical pain means neurasthenia or something allied to it. By geometrical pains I mean those in points, lines, squares, circular areas, parallelograms, triangles, etc. But here again it is to be remarked that a geometrical pain is rarely a veritable pain, but rather a pressure, or a heat, or a coldness, or a drawing, or some other dolorous paresthesia.

"Notably peculiar is the negative attribute of neurasthenic headache that, no matter how severe it may be, it allows the sufferer to sleep.

"... More than any other headache, it is amenable to diversion. . . .

"With the exception of such transient relief as may be obtained by medicines or diversion, the headache of neurasthenia tends to be constant or nearly so. Patients who are 'always conscious that they have a head,' are 'never free from headache,' 'have not a moment's peace,' 'have had a headache for three years,' etc., are nearly always neurasthenics, and this continuousness separates their headache sharply from migraine and neuralgia. He who has had a headache for three months is pretty sure to be suffering from neurasthenia, or from grave organic disease." (Patrick: *Every-day Headaches*, Medicine, January, 1901.)

The statement, "I have had a headache every day, all day, for twenty years;" is the give-away. If the patient does not know how a normal head feels, how does she know she has a headache? Meanwhile, nutritionally, such patients blossom like the rose. How, one asks argumentatively, can a person really suffer and still gain weight or at least retain the weight stationary, eat well, have clear eyes and complexion?

3. **Eyestrain.**—Headaches from eyestrain, I think, are fairly frequent, though there is usually a neurotic element mixed in with them. At least the patients are hypersensitive to pain. The diagnosis is made on the therapeutic test: if glasses banish the headache, what more need be said?

All headaches of ocular origin are not included under eyestrain. In a middle-aged patient whose headaches began within a few months or weeks of consultation, *glaucoma* must always be ruled out. *Iritis* should be fairly evident when an etiologic factor.

4. Indurative Headache (Chronic Headaches of Questionable Etiology or Which Are Infrequent).—This term was introduced into medical counsels about thirty years ago. Edinger said it was the most frequent form of headache. The idea came apparently from Swedish masseurs who found that in certain cases of headache there was considerable tenderness in the occipital and suboccipital regions, that these sites were the locations of indurations of a rheumatic nature, and that the headaches were relieved by massage. I, myself, living in a locality at a time when we had no skilled masseurs, have rubbed away diligently at a number of these indurations and, sure enough, I cured many a headache. But skepticism, that enemy of the pocketbook, kept creeping in. I became like the little boy in "The Emperor's New Clothes." Suddenly one day I found I could not feel the nodes, and the conviction deepened that I had never felt them. Dr. Hugh Patrick, although an advocate of indurative headache, wrote (*J. A. M. A.* 71: No. 2, July 13, 1918): "I think the nodules as generally described have no analogy in disease elsewhere in the body, and not often have I been able to feel them. My experience with masseurs is that they nearly always feel something abnormal. Norstrom naively advises one to examine the nodules during an attack of pain as otherwise they may not be found. Obviously this means that the observer does not feel them, but the patient does."

I believe all cases of so-called indurative headache are either neurosis or migraine.

5. Headaches of Nasal Origin.—Gruenwald, of Vienna, taught that headache was present in 100 per cent of the cases of acute sinus disease and in 50 per cent of the chronic cases. I would say that the latter figure is too high. Deaton, in a consecutive series of 270 cases of chronic sinusitis, found headache the chief complaint in less than 1 per cent.

6. Infection in the Nose as the Cause of Headache.—Acute upper respiratory infections produce headache due to nasal obstruction; it is usually dull and of varying intensity, located in the supraorbital region.

Sinusitis produces headache which may be periodic or constant, intensified by a jar or stooping, usually located in the intraorbital region or at the root of the nose.

Acute frontal sinusitis produces headache that may be intermittent or pulsating, at times radiating to an entire half of the head. It is often so excruciating that sedatives fail to control it.

Acute ethmoiditis produces headache, associated with lacerimation and a feeling of burning and pressure in the eyes.

7. Obstruction in the Nose as the Cause of Headache.—Tremble (*Headache of Nasal Origin*, *Canad. M. A. J.* 50: 43, Jan., 1944) believes that aside from infection any anatomic abnormality or obstruction may cause nasal headache. He lists high deflection of the septum to the affected side, a large boggy middle turbinate, polypi in the middle meatus, or even swelling of the mucous membrane due to allergy, ridges or spurs on the septum, particularly along the upper border of the vomer which may impinge against the inferior or upper turbinate.

Persky (*Headache of Otorhinologic Origin*, Clinics 1: 76-86, June, 1942) warns against concentration on the otorhinologic factors in headache.

Obviously the post hoc ergo propter hoc fallacy may be the pitfall here. There are so many noses that have some deviation from the normal, and so many people with chronic headache that the number of those with both is a statistical probability. The merely uncritical conclusion that when one is found it is the cause of the other will lead to more or less serious consequences.

Sluder's lower half headache or Sluder's neuralgia is due to involvement of the splenopalatine (Meckel's) ganglion, usually due to nasal infection. "Lower half headache, when complete, is pain in and about the eye, the upper jaw and teeth, extending back about the zygoma into the temple, the ear, mastoid, worse usually 5 cm. back of the mastoid with tenderness to pressure to the occiput, neck, shoulder, shoulder blade, arm, forearm, hand and fingers, with often a sense of pepper or mustard burning in the nose." (Sluder: *J. A. M. A.* 77: No. 9, Aug. 27, 1921.) Sneezing, vertigo, photophobia, and occasionally choked disc may accompany it.

8. **Acute Otitis Media** produces pain located in the ear proper. In some cases the headache extends to the entire side of the head.

9. **Hypertensive Headaches.**—Considering the frequency incidence of hypertension, headache is a rare complication. But occasionally in young malignant hypertensive patients, it may be the first and presenting symptom.

10. **Syphilitic Headache.**—Headache is common in all stages of syphilis. It may be the only and presenting symptom in many an innocent victim; it may cause chronic invalidism, the real cause of which goes for a long time unsuspected. Many a woman has had colon irrigations, ovariectomies, ventral suspension, teeth and tonsils removed for a persistent headache when a Wassermann would have cleared up the whole puzzle.

11. **Temporal Arteritis.**—This is a queer entity. It affects men over fifty, produces headache, there is thickening and tenderness of the temporal artery and after a few months spontaneously goes away. (Horton and McGarth: *Proc. Staff Meet., Mayo Clinic* 12: 548, 1937; also Jeghers: *Proc. New England Heart Assn.*, March 25, 1940.)

12. **Brain Tumor.**—The proportion of headaches due to brain tumors differs widely with the kind of clinical material a physician handles. In a general outpatient medical clinic they are rare; in a neurosurgical clinic, fairly common. Every patient with a chronic headache deserves an examination of the fundus oculi.

13. **Tic Douloureux (Trigeminal Neuralgia).**—The diagnostician can hardly mistake this truly prostrating disorder. It occurs in late middle age and old age almost exclusively. It is probably primarily a disease of the Gasserian ganglion, degeneration being due to arteriosclerosis, although definite pathology is difficult to prove. The pain attacks suddenly, either in the distribution of the ophthalmic, the maxillary or mandibular branch of the nerve, or all three or any two. It is of a particularly excruciating character. The patient is forced into immobility by the spasm, even the facial muscles; tic is a misnomer.

Lacrimation is profuse. While diagnosis should hardly ever be missed, it happens, with serious consequence, to the extent of extraction of all the teeth on one side.

B. Thoracic Pain*

CAUSES AND RELATIVE FREQUENCY

1. **Fatigue Neurosis.**—Often labeled with what Cabot called "the bombastic term, pleurodynia." Intercostal neuralgia is an equally objectionable term because it commits one to a specific pathology. The diagnosis is made by exclusion of organic disease. It is transitory and not serious.

2. **The Anginal Syndrome.**—In the middle- and old-age groups this is easily the most frequent cause of thoracic pain. It is fully discussed on pp. 366-376. The pain of angina is almost certainly of the type due to ischemia of a muscle. There is no question as to the reality of this relationship. Lewis, Pickering and Rothschild (*Heart* 15: 359, 1931) subjected it to careful experimental tests. Using an apparatus which by the armlet of a sphygmomanometer shut off the blood supply, and a grip machine which measured the amount of muscular contraction of the flexor muscles, they found that "after a time the arm becomes the seat of a disagreeable, aching pain, gradually becoming so nearly intolerable that the exercise must be brought to an end."

3. **Pleurisy, Including the Onset of Pneumonia, Fibrinous Pleurisy, Pleural Effusion, Sero-fibrinous Pleurisy.**—These are the most frequent cause of thoracic pain—after pleurodynia—in the younger age group, up to the age of forty-five. The parenchyma of the lung is insensitive to pain. The trachea and primary bronchi are somewhat sensitive, giving rise to the feeling of sub-sternal soreness experienced at the onset of a cold, hardly to be called a pain.

The visceral pleura, according to Capps (*Arch. Int. Med* 8: 717, 1911) is insensitive, but the parietal pleura is very sensitive. Inflammation of the parietal pleura gives rise to strictly localized pain, exactly over the site of the involvement.

In many pleuritis the diaphragmatic pleura is involved. It is innervated by the phrenic nerve and the last six intercostals. The central portion of the diaphragm is innervated by the phrenic alone. If inflamed or irritated, pain is referred to the neck. The peripheral rim of the diaphragm, 2 or 3 inches wide, innervated by the lower intercostals, when inflamed or irritated, produces referred pain in the lower thorax, the lumbar region, or the abdomen.

4. **Pericardial Pain.**—Considering the incidence of rheumatic pericarditis, this should be the commonest cause of thoracic pain in children. There is sharp contradiction in the classical literature as to whether inflammation of the pericardium causes pain. Hirschfelder (*Diseases of the Heart and Aorta*, Philadelphia, 1910, J. B. Lippincott Co.) stated: "In simple fibrinous pericarditis, precordial pain is the most striking symptom" while Mackenzie (*Diseases of the Heart*, London, 1908, Frowde) said: "Dry pericarditis is essentially a painless complaint. This curious painlessness has long puzzled me."

*The discussion of the physiologic-pathologic basis for abdominal pain also applies to thoracic pain.

Capps (Arch. Int. Med. 40: No. 5, Nov., 1927) by experimentally introducing a silver wire through a paracentesis cannula into the pericardium, concluded that neither the visceral nor the parietal pericardium had pain sense. But the diaphragmatic pleura is so often involved in pericarditis that the typical referred pain either in the neck or over the lower thorax or upper abdomen is produced. In pericarditis with large effusion patients complained of dyspnea and a "tight feeling" or oppression over the heart, but not pain.

5. Other Causes of Thoracic Pain.—It is difficult to determine their relative frequency.

Acute, sudden, explosive, associated usually with collapse. Acute pneumothorax, dissecting aneurysm (see Schnitker and Bayer: Ann. Int. Med. 20: 486, March, 1944), pulmonary embolism, and infarct (q.v.).

Herpes zoster—prodromal stage—may lead to humiliating mistakes unless constantly kept in mind. The pain is more severe than in pleurisy. The absence of physical signs in the presence of indubitable excruciating pain of radicular distribution should suggest it. After the eruption, of course, the diagnosis is seldom or never in doubt.

CHRONIC, GRADUAL, OR RECURRENT.—

Aortitis and Aneurysm.—Pain is mostly substernal, sometimes referred to arm, neck, or abdomen. May be steady and boring, or anginoid in its periodicity, recurrence, and relation to effort. Paroxysmal attacks of dyspnea may accompany or replace the attacks of pain. Differential diagnosis may obviously be troublesome. The diagnostician will find more physical signs, however, on the average, in cases of aortitis, than in angina or coronary thrombosis: the x-ray evidence may be positive, the Wassermann is certainly suggestive and the electrocardiogram may be helpful.

Spondylitis, Radiculitis.—Radicular pain may imitate anything, but is likely to be chronic rather than recurrent, bilateral and segmental. This cause should always be considered whenever the diagnostician is confronted with chronic persistent chest pain. (See Smith and Koontz: *Deformities of the Thoracic Spine as a Cause of Anginal Pain*, Ann. Int. Med. 17: No. 4, October, 1942; and Gunther: *Pain of Nerve Root Origin in Hypertrophic Osteoarthritis of the Spine as a Confusing Factor in Diagnosis*, J. Lab. and Clin. Med. 15: No. 12, September, 1930.)

Tabes Dorsalis—girdle pain, a subdivision of the above.

Slipping Rib Cartilage Syndrome.—"Loosening of the costochondral cartilages of the lower ribs, notably the eighth, ninth and tenth, either by displacement of fracture fragments or dislocation of the cartilage, or more often by curling of the end of the loosened cartilage, so that on respiration or motion the deformed end slips over the ribs against the inside of the rib above with a click that is felt by the patient in some cases and with a severe and incapacitating pain." (Holmes: New England J. Med. 224: No. 22, May 29, 1941.) The cause may be either acute trauma or chronic trauma or multiple minute injuries as from golfing or one-sided weight carrying. Digital examination with the patient in the supine position will reveal the movable cartilage,

associated with a click and a pain. "Because of failure to recognize the symptom-syndrome, needless laparotomies have been performed and prolonged suffering and incapacity from an easily curable condition are often permitted." (Holmes, op. cit.)

Gumma of the sternum, costal neoplasm, costal actinomycosis, must be considered.

Mediastinal growths seldom produce pain, rather pressure symptoms.

Unilateral rupture of the sixth cervical intervertebral disk produces pain in the neck radiating to the shoulder, precordium and arm, and sensory changes in the index and middle fingers. It has been mistaken for angina. Minor trauma—bending over to tie a shoe, jerking due to sudden automobile stopping or starting—is sometimes the cause: often the cause cannot be determined. There is a long history of crick in the neck (Semmes and Murphy: J. A. M. A. 121: 1209, April 10, 1943).

C. Pain in the Arm, Shoulder, and Neck

Cabot (*Differential Diagnosis*, W. B. Saunders Co., 1919) listed the relative frequency of causes of brachial pain on the basis of hospital record statistics as follows: *Arthritis, subdeltoid (subacromial) bursitis, fatigue and occupational neurosis, osteomyelitis, aneurysm, neuralgia* (cause not specific), *mediastinal tumor, neoplasm of arm or shoulder, cervical rib, angina pectoris, embolism*. (Trauma, infection, and wounds not represented.) The scalenus anticus syndrome causes pain in the side of the neck radiating over the clavicle in front, down over the shoulder and upper extremity into the hands by way of the course of the radial, ulnar, and median nerves (Hansson: S. Clin. North America 22: 611, April, 1942).

D. Abdominal Pain

General Considerations.—Pain itself is a sufficiently controversial subject, evading a strictly physiologic explanation, but visceral pain, especially abdominal, has particularly attracted varied and antagonistic hypotheses.

The stumbling block to a unified conception lies in the fact that the abdominal viscera are insensitive to pain, but disease of these viscera undoubtedly, under certain circumstances, gives rise to a sense of pain which is localized on the surface of the abdomen and to localized cutaneous hypersensitiveness.

LENNANDER'S EXPERIMENTS.—For centuries—in fact, until 1900—there was probably no medical man, no matter how well-informed, who would even have thought of any other explanation for a pain in the abdomen than that a viscus—the stomach, the liver—was diseased and the disease stimulated its pain nerves. About 1900 Karl Gustav Lennander, of Stockholm, began to report on his experiments in patients under local anesthesia. They were conscious and could respond to questions. He found that when he had thoroughly anesthetized the abdominal wall and parietal peritoneum, he could squeeze, cut or burn the solid viscera—liver, spleen and kidney—without eliciting pain. The stomach, duodenum, gall bladder, jejunum, ileum, pancreas, colon, appendix and great

omentum could be clamped, burnt, cut, without pain. Stretching produced pain in the duodenum and appendix, but not the stomach or small intestine. Traction on the stomach and jejunum-ileum, however, caused pain, probably by the drag on the mesentery. Strong contraction of hollow organs (cramp) also produces pain. Lennander, and everyone else who has ever performed such experiments, found the parietal peritoneum to be sensitive to all kinds of stimuli.

These experiments have been repeated by a number of observers with approximately the same results and are generally accepted.

ROSS.—Lennander's only predecessor in the field was James Ross, of Manchester, who published a theory of visceral pain in *Brain* in 1887. He stated that there were two kinds of pain, splanchnic and somatic, the splanchnic pain arising in the organ, and the somatic, in the cerebrospinal nerves of the body wall, connected with the same segments of the cord as the affected splanchnic nerves. "The splanchnic nerves of the stomach are derived from the fourth, fifth and probably the sixth dorsal nerves, and when the splanchnic peripheral terminations of these nerves are irritated, the irritation is conducted to the posterior roots of the nerves and on reaching the gray matter of the posterior horns, it diffuses to the roots of the corresponding somatic nerves, and this causes an associated pain in the territory of distribution of these nerves, which may appropriately be named the *somatic pain*."

MACKENZIE.—ROSS apparently never attempted anything like Lennander's experiments and it never occurred to him to doubt the existence of splanchnic pain, but his views of the spreading of afferent impulses through the cord to the segmental sensory roots had a great influence on James Mackenzie, who began to experiment on visceral pain and formulated an hypothesis which was finally summed up in a monograph entitled: "Symptoms and Their Interpretation," first published in 1912. (Hoerber.)

Mackenzie tells an anecdote of a consultation with another physician which illustrates his views. The patient had pain in a limited area on the skin of the epigastrium. The diagnosis of gastric ulcer was agreed upon and Mackenzie asked the consultant the question if he wished to plunge a long *hatpin* through the center of the ulcer, where, on the skin, would he place the point of the pin. The consultant said in the center of the spot of hyperalgesia. Yet at operation the stomach was found dilated and displaced, and the ulcer area was in reality in the hypochondrium to the right and about on the level with the umbilicus.

It is obvious that the stomach may carry its ulcer into nearly any region, but the area of pain and sensitiveness remains fixed.

Mackenzie's theory of visceral pain was that a diseased viscus sends afferent impulses through the splanchnic nerves (sympathetic) which reach the cord and create an irritable focus which stimulates the sensory and motor nerve roots. This stimulation results in the only response the nerves are capable of—in the case of the sensory nerves, pain, just as the stimulation of the optic nerve will produce only sensations of sight, and stimulation of the auditory nerve, sensations of hearing—distributed in a localized and fixed

area on the somatic skin segment. In the case of the motor nerves it produced spasm and rigidity of the muscles. These are respectively what Mackenzie called the viscerosensory reflex and the visceromotor reflex.

LIGAT.—In *The Practitioner* for August, 1916, Mr. Ligat recorded observations which extended those of Mackenzie. He reported localized hyperalgesia to ordinary stimuli in the skin of the abdominal wall in visceral disease. His method was to "grasp the skin and subcutaneous tissue firmly between finger and thumb and draw them away from the deeper layers of the abdominal wall. If a hyperalgesic area be present, the patient winces and one can tell by the patient's expression when such an area is being stimulated." The facial expression should especially be watched: the visible wincing converts "a subjective symptom virtually into an objective sign."

He mapped out seven of these hyperalgesic areas corresponding to classic intra-abdominal disease:

1. Epigastrium in gastric and duodenal ulcer.
2. Right hypochondrium for gall bladder disease.
3. McBurney's point for appendicitis.
4. Lower right abdomen near pelvic rim for right salpingitis.
5. Umbilical region for small intestine.
6. Hypogastrium for large intestines.
7. Lower left abdomen near pelvic rim for left salpingitis.

HURST.—In 1911 Dr. A. F. Hurst in the Goulstonian lectures on "The Sensibility of the Alimentary Canal," while agreeing with Lennander that the viscera could be cut, burnt or pinched without pain, brought forth evidence that contradicted Mackenzie's statement that there is no such thing as visceral pain. When the esophagus, stomach, and colon are put under tension, pain results. He believed that increased peristalsis in the intestine produced visceral pain, vaguely localized in the center of the abdomen and that this is not due to stimulation of the sensory nerves of the abdominal wall.

Hurst later abandoned the theory that when the stomach suffers from inflammation or tissue destruction, it is insensitive to pain, basing this on the fact that when an ulcer is visualized by the fluoroscope, pressure over the exact area of the crater elicits deep tenderness.

MORLEY.—Mr. John Morley of Manchester gave a great many years of consideration to the subject and in 1931 summarized his ideas in a valuable monograph entitled "Abdominal Pain" (Edinburgh, 1931, Livingstone). He criticized nearly all the previous theories, which are outlined above. Particularly he differed from Mackenzie's idea that afferent impulses from the viscera were relayed through the splanchnic (autonomic) nerves: "There is neither physiological nor histological evidence for the precise connection between the autonomic and cerebrospinal afferent nerves." He attributes most visceral pain to the associated localized inflammation of the parietal peritoneum and states that the afferent impulse, through the ordinary peripheral sensory nerves, results in pain which is ascribed to the segmental somatic distribution of the skin, and when the impulse is strong enough, it spills over into the cor-

responding motor segment, causing rigidity. He substitutes the names "peritoneocutaneous reflex" and "peritoneomotor reflex" for Mackenzie's terms "viscerosensory" and "visceromotor" reflexes.

Morley, by his experiments on shoulder tip pain, proved that it occurred as a result of irritation of the diaphragmatic peritoneum. He reemphasized that the mechanism of this lay in embryologic descent of the diaphragm from the neck and shoulder region. The shoulder tip pain is therefore a reflex, referred to the skin area of distribution of the sensory nerves developed while the diaphragm was in that region.

KINSELLA'S PATIENT.—Kinsella (*Lancet* 1: 711, 1929) threw a monkey wrench into all this speculation by reporting a paraplegic patient with a complete severance of the cord at the third dorsal vertebra in whom an enema caused a colicky abdominal pain. All the commentators writhe over this. Morley explains it by assuming that some intact fibers existed from the splanchnic nerves to the cord, but if so, it would seem that Kinsella would have so stated. It seems to prove that impulses to the sympathetic can be transmitted perhaps by the vagus to the sensorium.

PALMER.—Peptic ulcer would seem to present conditions which would readily explain on a common-sense basis the pain associated with the disease. There is an open ulcer, exposing a raw surface and nerve endings (if any exist), and a chemical irritant, hydrochloric acid, in contact with the raw surface. Furthermore the pain is relieved by neutralization of the acid. But many observers—Hurst, Schmidt, Hardt—introduced various strengths of hydrochloric acid into both the normal and ulcerated stomach, without producing pain. Reynolds and McClure (*Arch. Int. Med.* 29: 1-11, Jan., 1922) reported even pouring hydrochloric acid directly on a duodenal ulcer by means of a Rehfuess tube without producing pain. It was then thought, in the light of these negative results, that it was not the acid, but increased peristalsis, which caused the pain. But a further set of observations with the x-ray and the intragastric balloon, indicated that pain was not felt at the moment of intense peristaltic activity. W. L. Palmer (*Arch. Int. Med.* 38: No. 6, Dec., 1926) repeated the experiments. He explained the discrepancies by showing that in ulcer there are sensitive periods. During such periods he was able to produce typical ulcer pain 324 times in 84 patients. No pains occurred 10 times in a distress period, and 70 times in a distress-free period. A gruel meal removed during a distress period caused pain when reintroduced, but not if neutralized before reintroduction.

Clinical Observations.—In the meanwhile during the period when these clinico-physiological investigations were being carried out, a large body of purely clinical observation was accumulating an entirely practical body of knowledge about visceral pain. This may be said to have started with Charles McBurney. These observations corresponded to the period of development of abdominal surgery when diagnosis was checked immediately after it was made by laparotomy and surgeons were naturally interested in linking up exact clinical syndromes to the existent pathology.

Dr. Charles McBurney of New York described (New York Med. Jour. 50: 676, 1889) his diagnostic point in acute appendicitis thus:

"The *exact* locality of the greatest sensitiveness to pressure has seemed to me to be usually one of importance. Whatever may be the position of the healthy appendix as found in the deadhouse—and I am well aware that its position when uninflamed varies greatly—I have found in all of my operations that it lay, either thickened, shortened or adherent, very close to its point of attachment to the cecum. This, of course, must, in early stages of the disease, determine the seat of greatest pain *on pressure*. And I believe that in every case the seat of greatest pain, *determined by the pressure of one finger*, has been very exactly between an inch and a half and two inches from the anterior spinous process of the ilium on a straight line drawn from that process to the umbilicus. This may appear to be an affectation of accuracy, but, so far as my experience goes, the observation is correct."

It came to be general knowledge among surgeons that the pain in acute appendicitis is located early in the attack in the epigastrium, moves to the umbilical region and then to the region of McBurney's point.

Another diagnostic maneuver in appendicitis was described by Dr. Thor-kild Røvsing Zentralbl. f. Chir. 342: 1257, 1907) as follows:

"Both patients showed such unusual sensitiveness to palpation that a careful examination of the region of McBurney's point seemed not only impossible but inadvisable. It occurred to me that the typical pain might possibly be elicited by pressure on the descending colon, in the *left iliac fossa*. I laid my left hand flat on the abdomen and with the right hand forced its fingers down against the colon, compressing it. The hand was then allowed to glide upward toward the sigmoid flexure."

A number of surgeons, notably Mayo Robson and Murphy, described the classical pain of gall bladder colic—centralized in the right hypochondrium, reflected around the right ribs and into the scapular region. Mayo Robson regarded his point of tenderness in gall bladder disease (see p. 448) as important and invariable as McBurney's point in appendicitis.

Mr. Berkely Moynihan (afterwards Lord Moynihan) described in a series of papers the typical pain of duodenal and gastric ulcer. (Lancet and Brit. M. J., from 1907 to 1913.) His most important papers appeared in book form with the title *The Pathology of the Living* (Philadelphia, 1910, W. B. Saunders).

Two excerpts from his writings are forever valuable:

"There are few diseases whose symptoms appear in such a definite and well-ordered sequence as is observed in duodenal ulcer. If the earlier history is well remembered, the patient will say that insidiously, almost imperceptibly, he began to suffer from a sense of weight, oppression or distention in the epigastrium after meals. At the first the discomfort may be capricious but it is not long before notice is taken of the fact that it comes usually two hours or more after food has been taken. Immediately after a meal there is ease: if pain or discomfort were present before, the meal relieves them. Many patients will volunteer the statement that the pains begin to appear 'When they are beginning to feel hungry' and I therefore suggested the term 'hunger pain' as descriptive of this particular symptom. It is very characteristic of

the pain that it wakes the patient in the night, and constantly the time of waking is said to be two o'clock. The relief of pain by food leads to the practice of keeping a biscuit or some other food or drink which can be taken at once.

"Throughout the whole period during which the pain is felt, the appetite remains good. Vomiting is very infrequent.

"The most characteristic feature enabling a diagnosis of chronic duodenal ulcer to be made is the periodicity of the symptoms and their recurrence from time to time in 'attacks,' their complete abeyance in the intervals. A cause can almost always be assigned for the onset of symptoms. The most common of all these causes is 'getting cold'; in consequence the great majority of the patients will say that the attacks are especially prone to come on in the winter months—December, January, or February.

"Many of the patients complain of 'heartburn,' 'waterbrash,' or 'acidity.' In some cases the intensity of the acid regurgitation may be such that all other troubles seem by comparison insignificant. The relationship of 'hyperchlorhydria' to duodenal ulcer has given rise to a great deal of discussion. The idea is deep-rooted that the symptoms of duodenal ulcer are due to an excessive acidity, 'hyperchlorhydria,' 'acid dyspepsia' or 'neurosis.' Every physician who has written upon the diseases of the stomach up to the present day believed that hyperchloridria has a functional disorder. If we read the work of one of the greatest authorities, Riegel, we shall find a very detailed description given of the symptom-complex attributed to 'hyperchloridria.' I believe that Riegel is describing not a functional disorder, but a genuine organic disease, duodenal ulcer.

"The symptoms so perfectly characteristic of duodenal ulcer may be present for years without producing any physical signs. It is, therefore, not necessary to the attaining of an accurate diagnosis that any examination of the patient be made: the anamnesis is everything, the physical examination is relatively nothing." (Moynihan: *Duodenal Ulcer*, Philadelphia, 1912, W. B. Saunders Co.)

And again:

"The work of the surgeon has shown, I think, that chronic ulcer of the stomach or of the duodenum is a far more common disease than was formerly believed and that a very large number of the protracted or recurring cases of indigestion are due to its presence. It is no long time since the symptoms due to ulcer were attributed to vices of secretion, to excess or deficiency of hydrochloric acid in the gastric juice.

"This is usually the story the patient tells:

"After food is taken the patient is free from pain: the period of an hour or two which follows a meal is the best of the day. At a time varying from one and a half to four hours after the meal a sense of uneasiness is noted in the upper part of the abdomen. A burning, gnawing sensation develops and there is a bitter taste in the mouth; with it may be eructations of food or gas, bitter and acid in taste. The pain, which gradually increases, may be relieved by belching or by pressure. As all patients discover for themselves, the taking of food relieves, so many of them carry a biscuit in their pockets or take milk or a dose of an alkaline medicine. The pain, it will be noticed, comes at a time when the patient should be beginning to feel hungry for the next meal: for this reason the term 'hunger pain' seems quite appropriate. The appetite is generally good. It is not unusual for a patient to say, 'I have a good appetite. I can take anything and I never vomit.'

"After a time—a few weeks, a month or two—the symptoms may gradually improve, or even disappear, to reassert themselves after a longer or shorter interval. The patient will then speak of having attacks of a certain duration. The attacks are more frequent and more severe in cold weather than in warm. I often see and operate on cases of duodenal ulcer which have been variously diagnosed as 'chronic gastritis,' 'acid dyspepsia,' or 'hyperchloridria,' but a slender acquaintance with the pathology of the living is all that is needed to connect the clinical history outlined above with a condition of chronic ulceration of the duodenum." (Moynihan: *The Pathology of the Living*, Brit. M. J., Nov. 16, 1907.)

Moynihan does not mention two signs that have come to be recognized by diagnosticians as an integral part of the duodenal ulcer complex—relief of the discomfort by alkalis, and the fact that the patient remains in good weight and nutrition.

The clinical features of the pain of *renal colic* have become classical. Centering over the upper lumbar region, it is reflected around the front, over the flank and into the spermatic cord and testis of the affected side.

W. J. Mayo, Wilson and Giffin (Surg., Gynec. and Obst. 5: July, 1907) clearly described sigmoid *diverticulitis* as a clinical entity, succinctly as "left-sided appendicitis." Most cases occur in persons past middle life. Constipation is an important factor in diagnosis. The diverticula are acquired, probably, by the accumulation of hardened fecal masses. Left-sided pain coming in spells and terminating by the discharge of foul pus per rectum is indicative of this disorder. A mass can usually be felt. Fistula into the bladder may be a complication. The diagnosis usually suggested is carcinoma of the sigmoid. The suddenness of onset is against carcinoma, but only exploratory laparotomy will determine the true nature of the condition in the average case.

Regional ileitis was first described by Crohn, Ginzberg and Oppenheimer in 1932. (See page 475.)

Referred Abdominal Pain.—Surgeons learned also to look out for pneumonias in which the pleuritic pain was referred to the nerve endings of the lower intercostal nerves—i.e., the abdomen, simulating appendicitis, cholecystitis, even with rigidity.

These clinical data have proved far more valuable in practical work than the experimental work of Lennander and his successors outlined above. Whatever the physiologic basis for visceral pain, we know that certain kinds of pain, which can be very sharply defined, are associated with certain diseases. And these patterns are remarkably stable and consistent and reliable. Considering the great differences in the personality and sensitiveness of different patients, it is striking how much alike their stories are about ulcer, cholecystitis, appendicitis, renal colic, angina, etc. The experimental observations do indicate why massive infiltrating disease, such as cirrhosis of the liver, metastasis or gummas of the liver, gastric carcinoma, can occur in the viscera without producing any sensations whatever.

Whether afferent impulses resulting in pain go through the splanchnic autonomic nerve or sensory peripheral nerves is not known. Probably both,

under varying circumstances. The parietal peritoneum is supplied with sensory nerves and irritation of this probably occurs in diseases of most of the viscera, which produce pain.

DIFFERENTIAL DIAGNOSIS OF ABDOMINAL PAIN

Relative Frequency of the Causes

General Abdominal Pain—Acute, Recurrent, Severe (Constipation and Labor not included—too numerous).—

	PER CENT
Diarrhea and enteritis	23.00
Appendicitis	26.00
Gall bladder colic and cholecystitis	17.00
Abdominal migraine	14.00
Neurosis, hysteria, emotional crisis	5.00
Intestinal obstruction, including strangulated hernia	2.00
Pneumonia—referred pain to abdomen	1.50
Mucous colitis	1.00
General peritonitis	1.00
Renal colic	1.00
Rupture of a viscus	0.90
Ectopic pregnancy	
Peptic ulcer	
Intestinal ulcer	
Gall bladder	
Coronary thrombosis	0.50
Gastric crisis of tabes	0.40
Diverticulitis	0.30
Lead poisoning	0.30
Tuberculous peritonitis	0.30
Regional ileitis	0.08
Acute metal poisoning	0.05
Acute pancreatitis	0.05
Mesenteric thrombosis	0.05
Henoch's purpura	0.05
Twisted ovarian pedicle	0.05
Amebic dysentery	0.05

(These tables are modeled on those in Dr. Richard C. Cabot's *Differential Diagnosis*, which have proved continuously valuable to me during the years. Cabot's tables were based on study of the records of the Massachusetts General Hospital, comparing the presenting symptom with the cause finally recorded on the hospital records. I have incorporated Cabot's statistics into my own based on study of the records of the Kansas City General Hospital, the University of Kansas Hospitals, and the University of Kansas Outpatient Department. Cabot recorded the number of cases: I have thrown them into statistical form.)

There are several conditions which simulate the classical conditions which produce abdominal pain, and if he is to avoid humiliating mistakes, the clinician should keep them always in mind.

Acute Pancreatitis.—The history is usually that in a middle-aged person who has had repeated attacks of indigestion or abdominal pain; there is a sudden agonizing pain in the epigastrium with vomiting and shock. This is explained by the pathology which is that of gallstones, one of which has become so wedged in the opening of the common duct as to force the pancreatic secretions back on the organ, causing necrosis.

under varying circumstances. The parietal peritoneum is supplied with sensory nerves and irritation of this probably occurs in diseases of most of the viscera, which produce pain.

DIFFERENTIAL DIAGNOSIS OF ABDOMINAL PAIN

Relative Frequency of the Causes

General Abdominal Pain—Acute, Recurrent, Severe (Constipation and Labor not included—too numerous).—

	PER CENT
Diarrhea and enteritis	28.00
Appendicitis	26.00
Gall bladder colic and cholecystitis	17.00
Abdominal migraine	14.00
Neurosis, hysteria, emotional crisis	5.00
Intestinal obstruction, including strangulated hernia	3.00
Pneumonia—referred pain to abdomen	1.50
Mucous colitis	1.00
General peritonitis	1.00
Renal colic	1.00
Rupture of a viscus	0.90
Ectopic pregnancy	
Peptic ulcer	
Intestinal ulcer	
Gall bladder	
Coronary thrombosis	0.50
Gastric crisis of tabes	0.40
Diverticulitis	0.30
Lead poisoning	0.30
Tuberculous peritonitis	0.30
Regional ileitis	0.03
Acute metal poisoning	0.05
Acute pancreatitis	0.05
Mesenteric thrombosis	0.05
Henoch's purpura	0.05
Twisted ovarian pedicle	0.05
Amebic dysentery	0.05

(These tables are modeled on those in Dr. Richard C. Cabot's *Differential Diagnosis*, which have proved continuously valuable to me during the years. Cabot's tables were based on study of the records of the Massachusetts General Hospital, comparing the presenting symptom with the cause finally recorded on the hospital records. I have incorporated Cabot's statistics into my own based on study of the records of the Kansas City General Hospital, the University of Kansas Hospitals, and the University of Kansas Outpatient Department. Cabot recorded the number of cases: I have thrown them into statistical form.)

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The gastric crises of tabes consist of severe general abdominal pain and vomiting. The vomiting is very severe—first food, then bile, then retching. Neither food nor drink can be held on the stomach. The attack lasts hours, or days, or weeks. The pain (lancinating pain) may occur without vomiting; the vomiting may occur without pain. There may be hematemesis due to ecchymoses in the gastric mucosa. X-ray film shows the stomach in a state of contraction, even hourglass spasm during the crisis. The gastric crisis may come early in tabes and be the first and presenting symptom. Every clinician has seen examples of patients with several laparotomy scars, all made under a wrong diagnosis, when the real trouble was gastric crisis. Nuzum (J. A. M. A. 66: No. 7, 1916) reported that in a group of 1,000 tabetics, 8.7 per cent were submitted to laparotomy under a mistaken diagnosis. The most frequent diagnoses were gastric ulcer, gallstones, appendicitis, salpingitis, and "exploratory laparotomy." In 17 per cent of the patients, the crisis was the first symptom of the disease. Had the nervous system and especially the spinal fluid been examined, the mistakes would probably not have been made.

The contrary situation may arise in tabes—anesthesias and paresthesias erasing the signs of serious visceral disease. Conner (J. A. M. A. 55: No. 17, Oct. 22, 1910) reported such a case of a man who clinically presented fever, vomiting, and leucocytosis with no pain and soft, nonrigid abdominal walls; at autopsy a perforated appendix with general peritonitis was found. These must be rare, however. Conner's paper refers to no other case in the literature.

Girdle pain is another symptom of tabes that has often led to unnecessary surgery. Dr. Hugh T. Patrick gave valuable hints concerning it. (International Clinics, Vol. II.)

"Aside from the typical lancinating pains of tabes, which are idiosyncratic, unlike anything else, many tabetics complain of pains and paraesthesiae which do not belong to this category. Of these quite a number will fall, on careful examination, under the class of girdle pains; but in inquiring for this symptom be careful not to say simply—"Have you a girdle sensation?"—because the patient does not recognize it as such. It were better to ask if he has pains in the chest or neuralgia in any part of the body, or pains in the stomach, etc. The girdle sensation is generally a pain and unless you inquire for pain you will not get what you are after."

Charcot wrote—"Besides the lancinating pains we have also in ataxia to take the constructive pains into consideration. The patients compare it to the constriction caused by an over-tight cuirass or a corset too tightly laced."

Pseudoappendicitis Due to Intercostal Neuralgia.—Dr. John Berton Carnett of Philadelphia wrote a number of papers (see Chronic Appendicitis Due to Intercostal Neuralgia, Am. J. M. Sc. 174: No. 5, Nov., 1927, and Acute and Recurrent Pseudo-Appendicitis Due to Intercostal Neuralgia, 174: No. 6, Dec., 1927) which are very valuable to those interested in the subject of "chronic appendicitis." Carnett does not believe in chronic appendicitis; appendectomy for chronic appendicitis fails to relieve the preoperative symptoms in a fairly high percentage of cases. What, then, is the cause of the abdominal pain that so frequently localizes over the appendix region? Carnett believes it to be intercostal neuralgia: the tenderness is in the abdominal wall. The

cause of the intercostal neuralgia is bad posture, scoliosis, kyphosis or lordosis, arthritis of the spine, dislocation, strain, etc., of the spine.

In cases of vague symptoms of abdominal pain and dyspepsia, Carnett advises a test which has proved valuable in my hands. The abdomen is palpated in the usual way to elicit tenderness. Then with the patient recumbent, he is instructed to raise his feet and legs stiff and unflexed. This tenses the recti abdominus, so that no tenderness elicited by palpation could possibly be due to tenderness of the viscera or peritoneum. If, when palpation is repeated in this position, tenderness is again elicited, it must be in the abdominal wall.

Another test of Carnett's is the pinch test of the skin—picking up a fold of abdominal skin and fat between thumb and forefinger. If this is tender, the pain of which the patient complains must be in the parietes.

Carnett has done a valuable service, especially to surgeons, in showing them that a very large number of patients who complain of abdominal pain do not have visceral disease. However, I do not follow his argument all the way. I do not believe there is a neuralgia or any nerve disease (he admits "intercostal neuralgia" is a bad term) present in these cases. Nor am I able to make out a spinal ganglion lesion in more than a small percentage and I do not believe it is a causative factor even when it occurs. These suggestions simply bring in another organic explanation and for this group of abdominal pains what the profession needs to learn is that they are functional and psychic. Carnett's pinch test is not as significant of nerve involvement as he asserted. These patients tend to be very "painful" whenever they are examined. The pinch test does not mean nerve disease.

Abdominal Psychalgia.—In a world which has had drummed into it for sixty years the dangers of appendicitis, every layman who has a twinge of pain over where he thinks his appendix is, stands a chance of being scared into an operation. And over a period of forty years the idea has gradually filtered into the layman's head that any kind of abdominal pain must be appendicitis, gallstones, or peptic ulcer. In a very large section of the medical profession this attitude is also held. They have a "prejudice for the organic"; they like a mechanical explanation for symptoms. Being healthy-minded themselves, it is difficult for them to understand the processes of personality which lead people to gravitate toward being chronically sick.

One of the outstanding contributions that the Freudian psychology made to clinical medicine is that it insisted with such emphasis on the frequency of these syndromes and the futility of treating them by mechanical methods, whether the method be surgery, drug therapy, diet, massage, vitamins, endocrines or what. Leaders of American thought in psychiatry, such as Menninger, Stecker and Horney, have made us less mechanistic and more aware of what Karin Stephen calls "the wish to fall ill." Especially gratifying is it to find surgeons, such as Carnett, and physicians, such as Pratt and Alvarez, working on this theme and carrying so many of their colleagues with them.

Psychalgia is a word that well expresses the pains of these patients. I first encountered it in a paper by Drs. Pratt, Golden and Rosenthal, of Boston

(The Psychalgias: J. A. M. A. 98: No. 6, Feb. 6, 1932), although they disclaim its coinage. A psychalgia can be localized anywhere, but abdominal psychalgia is the commonest form. A striking point about psychalgia is that it is quite localized. Bloecq gave these pains the name "tapalgias" from *tapos*, a place, and *algia*, a pain, but this does not emphasize the psychic origin as does "psychalgia."

Sir Benjamin Brodie gave a graphic analysis of such a pain, as follows:

"A middle-aged lady, who had been exposed during a considerable period of time to the operation of causes of great mental anxiety, complained of a constant and severe pain, which she referred to a spot, about three or four inches in diameter, in the situation of the false ribs of the left side. Besides this, she was subject to fits, apparently connected with hysteria, and otherwise in a very impaired state of health. Under these circumstances, she died, and on examining the body after death, particular attention was paid to the side to which the pain had been referred. No morbid appearances could be detected in it, there was neither inflammation, nor thickening, nor any morbid change of structure, not the slightest deviation of any kind from the natural condition of the part.

"Now such a case as this is by no means uncommon. It is only one of many which might be adduced in proof of this proposition, namely, that the natural sensations of a part may be increased, diminished, or otherwise perverted, although no disease exists in it which our senses are able to detect either before or after death." (Brodie, Benjamin: *Lectures Illustrative of Certain Local Nervous Affections*, London, 1837.)

Sir Benjamin saw these painful spots, particularly around joints. "Since I have engaged in a large private practice, they have presented themselves. I may say without exaggeration almost daily." And although a patient with an hysterical hip joint will wince and scream when pressure is applied to the joint, "she does the same if you make pressure on the ilium, or even on the side as high as the false ribs, or on the thigh or even on the leg as low as the ankle. If you pinch the skin, lifting it at the same time from the subjacent parts, the patient complains more than when you forcibly squeeze the head of the thigh bone into the acetabulum." But "if her mind be occupied in conversation, she will scarcely complain of that which would have occasioned torture otherwise."

A great group of these patients are those which have been described as having "constitutional inadequacy." (See p. 186.)

Visceroptosis has been invoked and emphasized by many as the real cause of these functional abdominal pains and dyspepsias. Here, too, I feel the clinician should proceed with caution. It is a stigma of constitutional inadequacy, but is it not simply another mechanical explanation for those who will not admit or cannot grasp pain due to a functional neurosis? There are numerous patients with visceroptosis who make no complaints at all, and many who are mechanically relieved of their visceroptosis who have their same old painful complaints.

Visceral Manifestations of the Erythema Group of Skin Diseases.—Osler (Am. J. M. Sc. 110: 629, 1895) first focused attention on this syndrome.

Schönlein (1837) had noted arthritis as a complication of purpura, and Henoch (Berl. klin. Wehnschr. 5: 517, 1868) intestinal hemorrhages in association with purpura, but Osler's contribution was different. He described cases of abdominal pain and colic of great severity, which preceded by hours or days the skin eruption of purpura or erythema multiforme and which could easily be mistaken for surgical abdomen. Joint swellings also occurred. Albuminuria was a constant feature. Most cases occur in children. In about 5 per cent of cases no skin lesions ever occur. Patients subject to purpura may have colic as a regular predecessor to the skin eruption. The cause of the abdominal pain is evidently extravasations of blood or serum over large areas of the intestinal wall.

Angina Abdominis.—Attacks of abdominal pain which are not infrequently diagnosed as carcinoma or ulcer of the stomach, gallstones, perforation, etc., but which are undoubtedly due to disease of the blood vessels, can occur. It was a favorite subject with Allbutt. He thought angina abdominis was due to disease of some part of the abdominal aorta. Osler, however, believed the attacks to be merely angina pectoris with an abdominal reflection of the pain. I saw a patient who always had anginal pains referred to the epigastrium, the electrocardiogram showing unmistakable evidences of coronary occlusion with infarction. At autopsy there was evident no special involvement of the abdominal vessels. The differential diagnosis should not be difficult if one keeps in mind the possibility of sudden agonizing abdominal attacks in arteriosclerotic persons; men are more frequently victims than women.

Mucous Colitis and Abdominal Allergy.—Mucous colitis is a functional disease of the colon consisting of recurrent attacks of abdominal colic with passage of large masses of mucus by rectum. Differential diagnosis between carcinoma of the bowel is often a problem. The finding of even small amounts of blood or pus in the stool should rule out mucous colitis. X-ray and sigmoidoscopic examinations are indicated. Abdominal allergy with similar manifestations has been described.

Lead colic is the commonest symptom of chronic lead poisoning—1,216 cases of colic, 101 of paralysis, and 72 of encephalopathy in Tangnerel's series. The pain is general, paroxysmal, relieved by pressure. Between attacks a dull pain may persist. Vomiting is not infrequent. Constipation is the rule at first; later in the course of the disease diarrhea accompanies the attacks. The x-ray shows, during the colic, spasms at localized spots in the intestines. It presents some features of an abdominal inflammatory disease, but the lead line, anemia, stippled red cells and history should set the clinician straight.

Herpes zoster—prodromal stage of pain. Similar to situation in thoracic pain. (See p. 91.)

Spondylitis.—Radicular distribution of pain from tuberculosis of the spine, the ankylosing spondylitis of Marie-Strümpell, etc. (See p. 106.)

Embolism of the superior mesenteric artery causes pain of extreme severity accompanied usually by vomiting and terminating in intestinal obstruction due to gangrene of the ileum. Arteriosclerosis is the usual cause. The pain is

general over the abdomen. Shock is profound. The correct diagnosis is seldom made. Moore (Brit. J. Surg. 28: No. 111, Jan, 1941) believes that an enema which results in bloody fluid is a diagnostic procedure of help. If an abdominal tap is made on account of fluid, the finding of bloody fluid is confirmatory of thrombosis. The thrombotic tissue can form adhesions with the mesentery and other structures and result in a mass, which is tender. The thrombosis may not necessarily result in bowel necrosis, so a long history is not necessarily inconsistent with that diagnosis.

Stitch in the Side Following Exercise.—This common experience has usually been ascribed to the descent of the spleen or swelling of the spleen, perhaps because that is where the discomfort usually is. But it was observed by Capps (Arch. Int. Med. 68: No. 1, July, 1941) to occur in 37 cases on the left side, as against 71 on the right. He believes it is due to anoxemia of the diaphragm. His explanation of why it is so invariably unilateral is that the person stops exercising before the other side is affected.

Other causes of abdominal pain are food poisoning, fecal impaction, and psoas abscess.

Renal infarction is a rare cause of abdominal pain. White and Porter (New England J. Med. 224: No. 17, April 24, 1941) collected reports on 143 cases. All were found to have heart disease. Pain in the side of the abdomen and flanks rather than at the costovertebral angle was universal. Nausea and vomiting were rare. Three patients had renal colic.

Prostatitis and seminal vesiculitis may cause acute or recurrent abdominal pain, usually in the lower segment. (See Freund: Ann. Int. Med. 17: No. 1, July, 1942.)

E. Backache

COMPARATIVE FREQUENCY OF CAUSES OF BACKACHE (Fatigue, Prodromes of Infectious Diseases, Pregnancy and Onset of Labor—too numerous to calculate accurately).—

	PER CENT
Sacroiliac strain	28
Lumbago	28
Posture	10
Neuroses or reflex (uterus, visceroptosis, etc.)	10
Noninfectious arthritis (including Paget's disease)	7
Herpes zoster	7
Renal colic	4
Tuberculosis of the spine	3
Renal abscess, tumor, etc.	1
Metastatic tumor	1
Miscellaneous causes	1

1. Infectious Arthritis.—

Tuberculosis of the Spine.—Pain is nearly always present. It may be local in the region of the disease or referred to any region to which the involved sensory nerves go. Thus intercostal neuralgia, abdominal pain, sciatica, may

be indications of tuberculosis of the spine. Night crises are the result of pain occurring during sleep when relaxation of muscles occurs.

Spasm and rigidity of the spine are usual accompaniments of the pain.

Characteristic postures should hint to the diagnostician that pain is present even when there is no complaint. When the cervical region is involved, the child rests his chin on his hands continually. When the thoracic spine is involved, there is distress on the face, walking is careful, and grunting on breathing is common. The "military attitude" of stiff spine, walking on tiptoe, and limp due to irritation of the iliopsoas muscle are reliable hints. The old test of asking the child to pick up an object on the floor, and having him do so not bending over, but by letting himself down by the knees is a form of "military attitude."

Ninety to ninety-five per cent of patients have the onset in childhood. There are few groups of clinical entities where diagnostic errors are so universal as in that where the process of tuberculosis of the spine begins in adult life.

I remember one humiliating experience when a gentleman, accompanied by his wife, came to my office to consult me about a perfectly typical girdle pain, exactly the girdle pain of tabes. As he was also obviously partially blind, I examined him first with an ophthalmoscope and found a marked choroiditis. Without examining his spine, I began to pronounce my verdict when he looked at his wife and said, "It's no use. He is like all the others. Pay him off and let's go." He said he was convinced that was not what was the matter with him and left. The next day his wife returned and asked me if my fee included an additional opinion. She asked me whether I could tell tuberculosis of the spine if I saw it on an x-ray film. I answered I thought I could, and she then produced a film that had been taken after they left my office the day before. The tuberculosis was perfectly evident, corresponding to the radicular distribution of his zone of pain. The only feature of the case I remember with any satisfaction is that I returned the fee.

It is astonishing how often tuberculosis of the spine goes undiagnosed, in children or adults, even in advanced cases.

Osteomyelitis of the spine occurs in 1.5 per cent of all cases of osteomyelitis (Wilenski: *Osteomyelitis*, New York, 1934, The Macmillan Co.). It occurs most often in young adults. The thoracolumbar vertebrae are most often affected. The onset is usually acute with localized pain and tenderness. A history of injury or skin lesions, such as boils, insect bites, septic fingers, or septic sore throat is the rule.

Brucellosis (undulant fever) of the spine is a late sequel, an osteomyelitis of the vertebrae which in most cases affects the lumbar region. It occurs in about 0.5 per cent of all cases. In the diagnostic identification of this cause of backache the history of the primary fever may be very vague or nonexistent. Many, if not most, cases of brucellosis go unidentified. The patient's primary consultation with the physician may be for backache. The pain is likely to be accompanied by fatigue, loss of appetite, constipation, or diarrhea,

insomnia, headache, etc. (See Phaler, Priekman and Krusen: *Brucellosis Spondylitis*, J. A. M. A. 118: No. 11, March 14, 1942.)

Typhoid spine is a sequel about which there still exists some debate as to its nature. It used to be regarded as a neurosis, but that idea has been completely given up. Whether it is a toxic degeneration of the muscle or a true arthritis is not settled. It may be a periostitis. "Typhoid inoculation spine" is a somewhat similar condition due to repeated protective injections. It affects usually the lumbar region.

Actinomycosis, blastomycosis, syphilis, and meningococci may rarely affect the spine.

2. Noninfectious Arthritis.—Von Bechterew described a gradually ankylosing process of the spine in 1892. In 1897 Strümpell and in 1898 Marie described what is probably the same disease under different aspects. Von Bechterew noted particularly the disturbances of innervation—pain, parasesthesias, atrophy of muscles. Strümpell noted the abnormal straightness or rigidity of the spine: he was impressed with the slight amount or absence of pain.

I agree with Durham and Kautz, who give a good review of the entire subject in historical form (*Spondylarthritis Ankylopoietic*, Am. J. M. Sc. 201: No. 2, Feb., 1941). They say that there is no basis for the use of the multiple names of Strümpell, Marie, and Bechterew, but that we should think in terms of spondylarthritis as opposed to other diseases of the spine, such as infectious spondylitis and hypertrophic osteoarthritis (spondylitis deformans and hypertrophic arthritis).

Herrick and Tyson (Ann. Int. Med. 15: No. 6, Dec., 1941) estimate that it occurs in about 0.2 per cent of all new patients presenting in an office practice of general internal medicine. It is most common in males of the third and fourth decade. The onset is insidious and slow in most patients, but occasionally it advances rapidly enough to be acute. The dominant symptom is pain. In spite of its severity the striking picture of the pain is its variability and vagueness, so much so that patients' descriptions are difficult to understand. Its location may be very diverse—back, hip, shoulder girdle, or sciatic distribution. It may be mistaken for subdeltoid bursitis, visceral abdominal pain, hip disease, sciatica. It is usually worse during the night. The patient is often awakened about 4 A.M. and stays uncomfortable until his morning hot bath eases him. Any sudden or violent movement, such as sneezing or coughing aggravates the pain. Activity, walking about, seems to make it better.

The second symptom in order of complaint by the patient is stiffness.

It is almost certainly the vertebral form of atrophic or rheumatoid arthritis.

Hypertrophic, or senescent arthritis is an overgrowth of bony processes which may be confined to lipping of vertebrae, or may throw connecting bridges of bony process over several vertebrae, producing complete ankylosis. Ankylosis of the sacroiliac joints is a common associated finding. The condition is very common, the vertebrae being the commonest site for hypertrophic or osteoarthritis; Hench states that 60 to 70 per cent of all persons over fifty years of age have some degree of it.

Menopausal arthritis is probably a variety of it.

Paget's disease affects the spine and results in slowly developing and disabling deformity, but in spite of the extensive changes pain in the back is not a permanent symptom: pain in the legs is always complained of. "The disease affects most frequently the long bones and the skull," wrote Paget, in the original description (*Medico-Chirurgical Transactions*, London, 1877), "and is usually symmetrical. The spine whether by yielding to the weight of the overgrown skull, or by change in its own structures, may sink and seem to shorten with greatly increased dorsal and lumbar curves. . . . In its earlier periods and sometimes through all its course, the disease is attended by pain in the affected bones, pains widely various in severity and variously described as rheumatic, gouty, or neuralgic, not especially nocturnal or periodical."

3. Neoplasms of the Back.—The vertebrae, being so largely spongy bone, are the particular site of metastases. Primary tumors of any kind which occur in bone may affect the vertebrae: osteoma, chondroma, bone cyst, giant cell tumor, sarcoma, myeloma, lymphoma (endothelial myeloma of Ewing), or fibrosarcoma. Pain may be absent or very prostrating. It is like all bone pain—worse at night.

4. Aneurysm can destroy vertebral bony tissue, and the pain resulting may be the first symptom of the aneurysm.

5. Postural and Mechanical Causes of Backache.—Scoliosis, kyphosis, and lordosis not due to some definite disease such as tuberculosis are very common and also difficult for the internist to assess. I have just seen a young woman who has had a series of seven laparotomies and wants another: she has a slight, almost imperceptible scoliosis to the extent that if you mark the spinous processes, they do not align. But for the life of me, I cannot say certainly that the abdominal complaints are due to the spine or hardly noticeable postural deformity.

Postural Strain.—Goldthwaite (*Am. J. Orth. Surg.* 7: 371, 1909) and Reynolds and Lovett (*J. A. M. A.* 54: No. 13, March 26, 1910) long ago called attention to this possibility. The faulty mechanical arrangement may be due to overweight, bad corsets, bad habit resulting in postural derangement or weak muscles. At any rate the center of gravity is displaced and strain is placed on muscles and joints where it should not be. The cases are usually easy to diagnose on account of lordosis or bad posture.

Postoperative Backache.—Cabot lists cases of postoperative backache as being too numerous to allow of accurate statistical listing. I long ago decided that postoperative backache was caused by the carelessness of surgeons, the result of position on the operating table. It occurs most frequently, and is almost inevitable, after perineal, vaginal, and rectal operations, where the patient's legs are strung up and under the anesthetic the lumbosacral fascia and articulations are under severe strain.

Neck pain forming a definite syndrome has been described by Jostes (*J. A. M. A.* 118: No. 5, Jan. 31, 1942). While neck pain may be due to bursitis, tendosynovitis, periarthritis, cervical rib, anterior scalenus syndrome or my-

ositis, the particular and frequent neck pain encountered by Jostes is due to asymmetry of the occipital condyles or atlanto-occipital joints. It can be made out only by the laminograph; an x-ray adaptation visualizes in sharp focus a particular plane of the body.

Ober's disease, or contracted iliotibial band, is associated with lame back and often some sciatica, a lateral deviation of the spinal column and tenseness of the fascia lata and iliotibial band. It can be detected by Ober's abduction sign. (See p. 295.)

6. Trauma.—Sacroiliac strain or dislocation or traumatic sacroiliac arthritis.

The sacroiliac juncture of the sacrum and ilium is a true joint, with hyaline capsule, synovial membrane, and synovial fluid: this, once in dispute, if memory serves me correctly, seems to be now the established opinion of orthopedic surgeons. These joints bear the entire weight of the body and transmit it to the pelvis and legs. It is particularly subject to trauma. "The lumbosacral joint," says Lewin (*Backache and Sciatica*, Lea & Febiger, 1943), "is at the crossroads of stress and strain. The trauma at this joint is like that which occurs when a train of railroad cars strike a bumper in a station." Very trivial everyday acts may cause a dislocation or strain of the sacroiliac—raising a window that sticks, kicking a football and either—(a) not connecting, or (b) connecting; stooping over to pick up a shoe, missing a step on the stairs, picking up grass on the golf course to see which way the wind is blowing, sneezing, moving furniture, putting a rug under a desk, extricating a locked automobile bumper, etc. An attempt should be made to bring these out in the history.

Orthopedic surgeons are still chary, however, of committing themselves to "dislocation" of the sacroiliac joint. They prefer the word strain. At any rate through irritation or slight repeated displacements of the sacroiliac, arthritis appears there. Hershey (*J. A. M. A.* 122: 983, 1943), examined 64 sacroiliac specimens and found hypertrophic arthritis in 25 per cent of them.

The pain of sacroiliac disease is not often definitely localizable by the patient. Often it is referred to the hip. It may radiate upward or downward. Posture brings it out. The patient sits on the opposite buttock from the affected side. He is unable to lie on the affected side. He walks upstairs one step at a time. Straining at stool aggravates the pain.

Rupture or displacement of the nucleus pulposus of an intervertebral disk has been frequently reported since 1932, when Mixter and Barr operated on a young man with severe intractable sciatica following a fall. (See Mixter: *Am. Surg.* 106: 777, 1937.) Seventy-eight per cent of cases present unilateral sciatic pain, 16 per cent bilateral sciatic pain, and 6 per cent backache alone. Of diagnostic value is the history of accentuation of pain on coughing, sneezing, or straining at stool, and the intermittency of the symptoms. Lewin ascribes this variability to the fact that the nucleus pulposus has the property of absorbing sixteen times its own volume of water. He also gives his suspected patients snuff, causing them to sneeze in his presence, to see if the pain

is aggravated. Pressure on a nerve by disk lesions is indicated by the aggravation of pain at night: 24 per cent of patients had pain sufficient to interfere with sleep.

Injuries of the spine may manifest symptoms after some time has elapsed. The paradox of an injury or supposed injury which lights up a previously existing disease such as tuberculosis must be remembered; also the possibility of malingering and compensation neurosis, the most famous of which went by the designation "railway spine." Herniation of the nucleus pulposus may not reveal itself for some months, and long-continued backache and sciatica may be due to this cause.

Spondylolisthesis means slipping of a vertebra: it is manifested by pain, weakness, and stiffness in the lower part of the back, sacroiliac region, and legs, and is relieved by recumbency. There is a forward and downward lumbosacral subluxation. A transverse groove in the lumbar part of the spinal column and spasm and prominence of the erector spinal muscles are signs. Trauma was the causative factor in 38 per cent of Meyerding's patients, usually landing on the buttocks in the sitting position. Trauma alone, according to Steindler, is not sufficient to account for the condition, congenital fissures or defective ossification of the vertebrae being necessary.

7. Fibrositis.—What is the pathology of lumbago? It is some sort of myositis with perhaps the formation of painful fibrous nodules. But, so far as I know, no one has ever made a biopsy to settle the matter. It is in my experience an epidemic infectious disease—even a contagious disease. Dr. Frank I. Ridge tells me, in a personal communication, of a married couple, patients of his: the wife came home from the Red Cross with lumbago: the husband was perfectly well when he came home that night, but the next day he also came down with lumbago. During an epidemic doctors are notably victims (exposure). Dr. R. C. Hart, an osteopathic practitioner of Chattanooga, Tennessee, writes me: "An interesting feature about lumbago is that it comes in epidemic proportions. We go along for several weeks with but a few sporadic cases, then all at once here they come in droves. Can it be possible that the condition is due to the invasion of a filtrable virus?" At any rate it is the cause of a third of all backaches.

Fibrositis of the muscles anywhere in the back have been ascribed as causes of backache. The indurations are palpable to gentle investigation. The common sites are the occipital insertion of the trapezius, along its edges and in the body of the lumbar muscles and the origin of the latissimus dorsi in the iliac crest. (See Krusen and Basom: *Certain Common Types of Low Backache*, M. Clin. North America, July, 1940. See also Jostes: *Low Back Lesions*, S. Clin. North America, October, 1940. See also Bell: *The Diagnosis and Treatment of Low Back Pain*, M. Clin. North America, November, 1940.)

8. Reflex.—Referred back pains from urologic and gynecologic lesions are to be judged very carefully. Among the lesions urologists list as causing back pain are perirenal infection, renal calculi, renal neoplasm, and cancer of the prostate. Novak (*Gynecology and Female Endocrinology*, Little, Brown and

Co., 1941) lists under backache due to pelvic disease: pelvic inflammation, pelvic tumors and perineal relaxation. Displacement of the uterus is no longer considered a cause. Novak says: "There is much difference of opinion as to the incidence of backache as a symptom of pelvic disease in women, many believing it to be quite rare, while others consider it frequent."

9. **Neurosis.**—Neurosis must never be forgotten as probably the most frequent cause of backache, overlooked or disregarded by the mechanically minded physician.

Neurosis of the spine, producing backache, is extremely common. The back bears the burdens of the world symbolically, and symbolically, when it can no longer do so, the back aches. A typical example was a young married woman who consulted me for backache with negative findings. On talking things over with her, I let out the remark that her life would be fuller and happier if she had a baby. At this, she became very indignant and said the Mayos had told her the same thing and how on earth could she have a baby with such a lame back? After long questioning the truth came out: that when she was mature enough to understand the circumstances, her mother had died in childbirth and she had developed a deep-rooted fear of doing the same thing. She used the back as an escape.

"Spineless" individuals are particularly liable to backache.

F. Pain in the Legs

Pain in the legs is caused by *flat foot*, *arthritis*, *Morton's metatarsalgia*, *varicose veins*, *osteomyelitis*, *tuberculosis*, *sciatica*, *phlebitis*, *bursitis*, *tenosynovitis*, *dissecting aneurysm* (see Gurin, Bulmer and Derby: New York State J. Med. 35: 1200, 1935; also New England J. Med. 225: 116, July 17, 1941), and intermittent claudication. (This last is ischemic muscle pain. See p. 516.) Behind the sciatica is a herniated nucleus pulposus in a certain proportion of cases.

The lancinating pains of *tabes* deserves a brief special consideration. They are, as Dr. Patrick said, *idiosyncratic*, unlike any other pain. Lightning pains is a good name for them. A patient was treated for twenty-five years for sciatica when a simple examination would have disclosed that the real trouble was *tabes*. Asked whether he had the pains all the time he replied: "No, they come in spells; the pains are terrible, I can hardly stand them." Asked how long these attacks of sciatica lasted, he replied: "Sometimes an hour; at other times three or four days. They come and go suddenly."

They may come on only while walking and be called intermittent claudication.

Chareot wrote: "The painful fulguration (or lightning pains) has but a transient duration, as its name indicates. It is repeated at varying intervals so as to constitute paroxysms which last four, five or eight days. The pain attains its maximum of intensity chiefly during the night."

Sciatica.—While nearly any pain in the leg is conveniently labelled sciatica, a fairly well-defined group of patients can be segregated who have pain

over the distribution of the sciatic nerve, and in whom we may assume there is inflammation, irritation or pressure in or on the nerve itself. Actual neuritis may occur in syphilis (lancinating pains of tabes), diabetes (possibly as a minor vitamin B deficiency due to the deranged metabolism).

Tumors of the cauda equina may cause sciatica, but are rare. Alcoholism or lead poisoning sometimes picks out the sciatic. In the commonly encountered form of sciatica, however, these etiologic factors are rare. Nor is the sciatica patient a neurotic. Every feature of such a case indicates that the nerve is subjected to stretching or distortion or pressure. For that reason I think the explanations of sciatica as due to pressure from an intervertebral disk or piriform muscle or disturbance at the lumbosacral junction of the spine have been received with such wholehearted acceptance by the profession.

The pathology of the intervertebral disk syndrome is described elsewhere (see pp. 692). Suffice it to say here that in making the diagnosis the history plays an important part. Trauma undoubtedly is the etiologic factor in practically all cases, but, as in sacroiliac strain, the trauma may be so slight that it is not remembered by the patient or not connected with the onset of the symptoms. Pulling at a sticking window, leaning over to retrieve a shoe from under the bed, moving furniture, lifting a heavy suitcase—all have been described in recorded case histories as sufficient to herniate the nucleus pulposus of an intervertebral disk. The sciatic syndrome may last for years unchanged and in a history taken long after the initial trauma be forgotten. The second point in the history is the distribution of the pain. Ninety-six per cent of protruded intervertebral disks occur at the fourth or fifth lumbar interspaces. These cause disability of the lower part of the back, with stiffness of the lumbar portion of the spine and localized tenderness over the fourth or fifth lumbar vertebra as well as sciatic pain.

In lesions at the third lumbar vertebra the pain will be in the front of the thigh rather than the back of the leg.

The pain was unilateral in 78 per cent of Love's cases, and bilateral in 16 per cent, with only low backache present in 6 per cent.

The third point in the history is the periodicity of the symptoms. The nucleus pulposus has the property of absorbing sixteen times its own volume of water: this may account for the intermittency of pressure symptoms (Lewin). The patients are good weather prophets. Humidity and rainy weather bring on the symptoms. Decrease in intensity of the pain by a change of position or going to bed, or change of position in bed indicates a mechanical lesion. Intensification of the pain by coughing and sneezing also is of significance.

II. ANESTHESIA, PARESTHESIA

Anesthesia may affect the skin, the joints, and the deep muscle and bone sense. Skin anesthesia may affect any or all of the primary sensations—touch, temperature, or pain. Paresthesia refers to perverted skin sensations—formication, tingling, haphalgnesia (pain in response to touch), etc.

Anesthesia is always due either to central or to peripheral nervous system involvement or to hysteria. The distribution of the area of anesthesia should allow the diagnostician to distinguish these.

Peripheral nerve section or injury results in anesthesia referred to the cutaneous area supplied by the nerve. Section of mixed nerves results in paralysis and loss of deep sensation as well. If regeneration occurs, sensation returns before motion.

Cervical rib, herpes zoster, multiple neuritis, nerve involvement from malignant disease of the spine and aneurysm are examples of *diseases* (not injury) which cause peripheral anesthesia. The anesthesia of cervical rib may produce a dissociation of sensation, as in the person of Dr. Barker, described by himself, with an area on the arm lacking in pressure and temperature senses, but retaining pain sense. (See p. 484.)

Multiple neuritis produces a usually bilateral anesthesia, often of sock and glove distribution. In lead palsy sensation is usually unaffected. Leprous neuritis causes a patchy, asymmetrical anesthesia.

Spinal cord lesions which cause anesthesia or paresthesia are *tabes dorsalis*, whether syphilitic or due to pernicious anemia, *syringomyelia*, multiple sclerosis, injury or tumor of the cord.

Loss of deep sensation nearly invariably occurs in *tabes dorsalis* and in Addisonian anemia, especially, is likely to precede the disability of gait. It can be demonstrated by attempting to elicit the sense of vibration with a tuning fork over the tibia. The patient is unaware of any change of sensation or else is puzzled by a change he cannot define, which consists in numbness of the soles of the feet and loss of the sense of position. This can be demonstrated by asking him to close his eyes and then decide whether the examiner has moved his big toe up or down.

Tabes dorsalis due to syphilis results in loss of pain sense in the testes and the glans; the tendo achilles and the calf muscles become insensitive and joint sense is progressively impaired. Biernacki's sign is loss of normal sensitivity in the ulnar nerve behind the elbow. Areas of anesthesia (preceded by analgesia) occur in the skin of the lower limbs, over the ulnar distribution and around the trunk (girdle or cuirass sensation). Astereognosis is likely to be present.

Syringomyelia produces dissociated anesthesia, with preservation of touch and loss of pain and temperature sense. Here again the patient may be unaware to the extent that he allows himself to be burned or injured. Loss of joint sensation and astereognosis are also present.

Section of the cord results in complete anesthesia below the level of the injury. Hemisection of the cord results in *Brown-Séquard paralysis*: this consists in motor paralysis, loss of sensation in the joints and muscles on the side of the lesion, and loss of touch, temperature, and pain sense on the side of the body opposite the lesion.

Cerebral and thalamic lesions produce hemianesthesia. Thalamic anesthesia has a peculiar property: when the skin is touched, paroxysmal pains of great severity are induced in the affected side, especially in the face.

Hysteria produces anesthesia rather than pain. It is a regrettable feature of modern practice that clinicians do not make a sharp and clear-cut definition of hysteria. They throw it into the wastebasket of the neuroses. Or they make a wastebasket of it and throw in anything they don't understand. I have enjoyed an enormous sense of clarity since accepting the definition of Pierre Janet, as long ago as 1907, when I first read his "Major Symptoms of Hysteria." Essentially he said hysteria is an amnesia—a forgetting. All the symptoms of hysteria—double personality, the somnambulisms, convulsive attacks, aphonias, contractions, blindness, changing of the visual field can be explained on that basis. The anesthesia of hysteria is the amnesia of a mental concept. A hand is anesthetic, the line stopping at the wrist rather than over the distribution of the peripheral nerves. Janet has an interesting story of an hysterical person who acquired an organic anesthesia on top of her hysterical anesthesia. The organic anesthesia bothered her very deeply although she had been utterly indifferent to her hysterical anesthesia. Universal anesthesia occurs only in hysteria.

Formication, the sensation of insects crawling on the skin, suggests impending uremia, or delirium tremens. Numbness and tingling of the fingers occurs in anemia and arteriosclerosis.

III. FATIGUE

Meakins recorded the presenting symptom or complaint of 1,000 patients. They were of every social status, and drawn from all walks of life. Only 49 different symptoms were found with any frequency in the entire group. Half of all the complaints consisted of 6 symptoms. In order of frequency they were: pain, weakness, loss of weight, fatigue, shortness of breath, and fever. (Meakins: *The Practice of Medicine*, St. Louis, 1940, The C. V. Mosby Co.)

Weakness and/or fatigue are like pain, subjective only. The clinician must accept the patient's word for it that he experiences weakness: there is no infallible sign to check the statement. True, the weak, tired patient looks weak—his gait is dragging, his face sags, his eyes look dull. But the neurasthenic can put on a woebegone look of fatigue, though he has been through nothing more strenuous than a week in bed.

Meakins makes a distinction between fatigue and weakness. Fatigue, he contends, indicates a depression of muscular function, while weakness is the result of a combination of factors—of which muscle fatigue may be one and metabolic disorganization another, but which is fundamentally a response of the nervous system to all of them. (Meakins: *Symptoms in Diagnosis*, Boston, 1941, Little, Brown and Company.)

Fatigue, then, may be purely physiologic following a more or less prolonged use of the muscles. Fatigue in the muscle results from reduction in the supply of oxygen and is accompanied by definite and well-understood chemical changes, as well as changes in temperature and electrical response. Any disturbance of circulation, or metabolism, the presence of toxins, irritation of the nervous system from lack of sleep, for instance, may therefore induce fatigue and weakness.

Allan (New England J. Med. 231, No. 12, Sept. 21, 1944) classified 300 patients whose chief complaint was either weakness or fatigue. In 80 per cent no physical disorder could be found. In the remaining 20 per cent the following causes were found:

	PER CENT
CHRONIC INFECTIONS - - - - -	4.3
Respiratory:	
Tuberculous - - - - -	3
Nontuberculous - - - - -	9
Urinary - - - - -	1
Syphilis - - - - -	1
METABOLIC DISORDERS - - - - -	4.0
Diabetes - - - - -	8
Myxedema - - - - -	4
NEUROLOGIC DISORDERS - - - - -	5.3
Myasthenia gravis - - - - -	4
Narcolepsy - - - - -	8
Psychomotor epilepsy - - - - -	3
Postoperative brain tumor - - - - -	1
HEART DISEASE - - - - -	2.7
ANEMIA - - - - -	1.7
Pernicious - - - - -	1
Hemolytic - - - - -	1
Secondary to cancer - - - - -	1
Nutritional - - - - -	1
Leucemia - - - - -	1
NEPHRITIS - - - - -	1.0
MISCELLANEOUS - - - - -	1.3

Pulmonary tuberculosis may have as its first and most annoying symptom, a fatigue that goes into the very marrow of the soul. One patient wrote that he would come home from a not very exhausting day of work and throw himself on the bed, so exhausted that every individual muscle fiber seemed to ache, and would lie there without even the energy to read, unheeding any of the movements of the household, dreading the call to supper, which would require the activity of going downstairs.

Addison's disease notably presents fatigue as a vocative symptom.

Hypoglycemia causes muscular fatigue for obvious reasons. Hyperinsulinism has as its first warning symptom what might be called acute fatigue. Portis and Zitman (*A Mechanism of Fatigue in Neuropsychiatric Patients*, J. A. M. A. 121: No. 8, Feb. 20, 1943) indicate that there is clinical and experimental evidence that the fatigue of neurasthenia is due to a mechanism of hyperinsulinism, due to temporary or prolonged stimulation of the right vagus nerve resulting from emotional processes being relayed through the hypothalamus to the autonomic nervous system. No injection of atropine which inhibits the vagus, in their experience, prevents this stimulation.

Myasthenia gravis is an example of purely muscular fatigue.

Anemia, heart failure (impending or existent), arteriosclerosis, diabetes, scurvy, neoplasm, and goiter must especially be remembered when seeking for an organic cause of fatigue.

The most frequent cause of fatigue, however, in adults at least, after eliminating infection, is neurosis. The word *neurasthenia* was coined to explain the group of those "born tired."

IV. ANOREXIA, HUNGER, THIRST, NAUSEA AND VOMITING

Anorexia, or Loss of Appetite.—The appetite fluctuates in health due to a wide variety of causes. Emotional disturbances, infections, lack of customary exercise, all cause temporary anorexia. As a symptom of chronic disease, it does not have a great deal of significance. Some people just naturally do not enjoy the pleasures of the table; they are never hungry—chronic dyspeptics, visceroptotics, and the like. In reduced metabolic activity, such as myxedema, anorexia nervosa, Simmond's disease, the appetite is diminished. In achlorhydria in pernicious anemia, it should logically be reduced, but in practice seldom is.

Jacobson and Palmer (*Gastroenterology* 1: 1133, 1943) fluoroscopically determined the gastric emptying time in a group of treated and untreated pernicious anemia patients. Significant prolongation in gastric emptying time occurred with one exception in those patients whose peripheral erythrocyte count was below 1.5 million.

Vitamin B complex in the diet probably stimulates appetite and its absence induces anorexia.

Hunger and thirst belong to the symptoms which may have either physiologic causes or pathologic significance.

The pathologic causes of hunger are diabetes mellitus, (starvation of the tissues from lack of sugar utilization), hyperinsulinism, and hyperthyroidism.

The pathologic causes of thirst are hemorrhage, diabetes mellitus, diabetes insipidus, chronic nephritis with polyuria, hypertrophic pyloric stenosis, dilatation of the stomach, ileus and shock.

Heat stroke is a condition on the borderline between physiologic and pathologic. In certain occupations (miners working in shafts so deep that the central heat of the earth heats the atmosphere, stokers and cooks in small and confined quarters) there is excessive loss of perspiration. This leads to abdominal cramps, muscular cramps, fatigue and thirst, and finally coma. It was found by industrial surgeons that if large doses of salt are given as well as water, the symptoms can be better prevented.

Nausea and Vomiting.—These may exist as entirely separate entities, but nausea is usually the precursor of vomiting. Existing alone it has not much clinical significance; it should suggest that there has been administration of some drug: the patient may be concealing the use of alcohol or morphine; he may fail to recognize the connection between his nausea and the use of digitalis. Psychic nausea is a definite entity. Pregnancy should never be overlooked as a possible cause.

Vomiting, with or without nausea, is one of the most important and significant symptoms met with in medical practice. Some people are easy vomiters, some are hard vomiters. The easy group empty the stomach almost at

will on the slightest provocation—indigestion or fear of impending indigestion, to avoid a hangover; for them emesis is a therapeutic procedure, just as the cathartic habit is for others, and the one they most frequently apply. The hard vomiter, on the contrary, may have gone through life and never known what it is to vomit. Most persons, of course, do not classify in either group, but it is important for the diagnostician to assess the vomiting history of his patient before he begins to assess the significance of any given attack of vomiting.

Vomiting is a complicated act. The "vomiting center" in the midbrain is a somewhat vague area, which probably receives impulses from the pharynx, or other parts of the body as well as from the stomach itself. Any of these points may originate the stimulus to vomit. The act itself depends on contra-innervation of various parts. There is a constriction of the stomach in the pyloric region, while the cardia and cardiac sphincter are relaxed: the propulsion of the gastric contents is done by the diaphragm and abdominal muscles.

From the diagnostician's standpoint it is of the utmost importance not to rush to the conclusion that vomiting indicates an acute local organic abdominal disease. Human nature being what it is, that is what he is likely to do. What he should think of first is *pregnancy*. It may be the first symptom of pregnancy that the woman pays any attention to: especially if it is the first pregnancy, she may entirely overlook the possibility of pregnancy: skipping of a menstrual period may have been disregarded as of no consequence, and her complaint to the physician is vomiting. Laparotomies have been mistakenly done under these circumstances more than once. The misinterpretation does not necessarily mean that the wife and husband are ignorant. When I was stationed at a base hospital in army service, the word got around that I was an eminent gastroenterologist and one of my first patients was the wife of a fellow medical officer, brought to me on account of nausea and vomiting, both high contracting parties being totally unaware that the real condition was pregnancy.

Food poisoning, acute digestive upsets (nature usually unidentified), the onset of infections (particularly scarlet fever), the gastritis and pharyngitis of alcoholism, and psychic emotional upsets, account for most cases of "acute" vomiting.

Aside from these, which were too numerous to be significant statistically, Cabot found in a consecutive series of unselected patients that gastric neurosis, acute appendicitis, and cardiac disease accounted for 90 per cent of the causes of vomiting. They were almost equally divided, cardiac disease forming 25 per cent. Nine per cent of all cases of vomiting were due to *peptic ulcer*, "*gastritis*," *intestinal obstruction*, and *gastric cancer*. One cannot help but believe that behind the "gastritis" and the gastric neurosis there were a good many cases of *gall bladder disease*.

Uremia and tabes make up a quarter of 1 per cent of his cases each.

Migraine is not included in his series, probably because he was dealing with hospitalized patients.

Cerebral causes include brain tumor and apoplexy, as well as concussion and skull fracture. Brain tumor is rare except on special services. The vomiting of apoplexy and skull injury hardly ever masks the real condition. Attacks of Ménière's disease are frequently complicated by vomiting.

Rare abdominal causes of persistent vomiting are hypertrophic stenosis of the pylorus, acute hemorrhagic pancreatitis, and acute yellow atrophy of the liver.

While these represent the usually listed conditions which may cause vomiting to be a diagnostic problem, there is hardly any condition of the body which may not induce vomiting at some time in its course. Vomiting is the primary reaction of revulsion of the organism to the assaults of the outside world.

V. WEIGHT CHANGE

A history of *loss of weight* always demands an explanation. Tuberculosis, diabetes, neoplasm, exophthalmic goiter, tabes, rheumatoid arthritis, are the commonest causes. Anorexia nervosa is a rare cause; so is Addison's disease. Worry, grief, melancholia with loss of appetite may result in weight loss, but the neuroses in general do not affect metabolism markedly.

Gain in weight, if of sudden onset and rapid development, indicates edema, evident or hidden, perhaps edema into a tumor. Splenomegally—myeloid leukemia, or Banti's disease—may not be evident to the patient.

Gradual gain in weight is characteristic of the passing of the years for about half to three-quarters of the human race. The rest, male or female, during the grand climacteric get a little thinner every year. There is a destiny that ends our shapes, rough hew them as we will.

Paradoxically, two organic diseases, pernicious anemia and duodenal ulcer, do not affect weight at all.

VI. PALLOR AND CACHEXIA

Transient circulatory changes in the skin resulting in pallor are most often due to emotional causes. Injury, shock, abdominal emergencies, and internal hemorrhage are the common organic causes.

Gradually deepening pallor is usually a sign of organic disease. (Or bad habits, such as living indoors and eating an unbalanced diet—"prison pallor.")

Chronic infections, notably tuberculosis and syphilis, produce quite characteristic pallor. When I was in college, the father of one of my fraternity mates, a physician, paid us a visit. Afterwards he said to his son: "That young man, Mr. A., has a venereal disease: no other pallor is like it." And so it proved.

Morphinism produces a pallor that may be either deceptive or a give away, as the case may be, depending on the experience of the observer.

Carcinomatosis, lead poisoning, nephritis, sepsis (such as chronic emphysema with amyloid change, cirrhosis of the liver, intestinal parasites, are other causes.

Anemia is paradoxically not a prominent cause. Chlorosis displays the "green sickness" look, but it is now rare. Addisonian (pernicious) anemia does not produce pallor, but a yellowish tinge, although, as has been said, there are yellow, bronze, and white pernicious anemias. Secondary and hypochromic anemia are more likely to produce a color change that could be called pallor.

The "cachexia of old age" is a pallor made up, in most instances of a combination of arteriosclerosis, atrophy of the skin, mild anemia, and increased indoor living.

It may, however, be caused by bundle branch block, which is far commoner than is generally supposed. The pallor and accompanying signs are very characteristic: the pallor comes on in a person of middle age somewhat abruptly: it is easier to recognize in a friend or acquaintance whom you have been accustomed to see frequently than in a stranger: the change is shocking. Along with it is a flabbiness of the subcutaneous muscles of the face and rapid loss of fat in the neck so that the skin folds lie loose and wrinkled. There is some accompanying limitation of activities, but no distressing dyspnea and usually the maintenance of a cheerful mental outlook.

The distinction between pallor and cachexia is not readily made. The dictionary definition of cachexia is "A profound marked state of constitutional disorder; general ill health and malnutrition." But the real changes are in the complexion and the weight loss which changes the facial expression. Perhaps cachexia is more yellow than white, but that is a matter I turn over to the dialecticians.

VII. SYMPTOMS REFERABLE TO THE DIGESTIVE SYSTEM

1. **Dysphagia.**—The act of swallowing requires the action of the musculature of the face, tongue, pharynx, and esophagus. Paralysis of facial muscles, tongue or pharynx then will cause difficulty of swallowing. These should be easy to identify. Diphtheritic paralysis of the pharynx must be remembered in the case of a child who during convalescence regurgitates food through the nostrils and ejects it from the mouth.

If the pharynx, tongue, and cheeks are not paralyzed, dysphagia means either esophageal obstruction or hysteria. Esophageal obstruction may be due to carcinoma, stricture, diaphragmatic hernia, cardiospasm, diverticulosis and hypochromic anemia with the Plummer-Vinson syndrome. (McGee and Goodwin: *Dysphagia and Anemia*, *Ann. Int. Med.* 11: 1498, 1938.) Merrill and Richards (*New England J. Med.* 225: No. 9, Aug. 28, 1941) report three cases of vitamin B deficiency with neuritis of the ninth and tenth cranial nerves, resulting in dysphagia. Tumors outside the esophagus rarely produce obstruction. Globus hystericus is a term which will remind us of the hysterical nature of obstruction.

Dysphagia due to disorders of the heart and great vessels is well reviewed by Bloomfield (*Am. J. M. Sc.* 200: No. 3, Sept., 1940). The dilated left auricle of mitral stenosis, pericardial effusion, sacculated aneurysms, dissecting aneur-

ysm, and anomalous aortic arch are the lesions found. When associated with pericarditis, it indicates a large effusion. Marked pain on swallowing, with aneurysm, suggests a false sac or threatened rupture. Dysphagia in a supposed case of coronary occlusion should arouse suspicion of a dissecting aneurysm.

Hilton Fagge (*Principles and Practice of Medicine*, Philadelphia, 1886, The Blakiston Co.) wrote: "So-called *dysphagia lusoria* demands a word of notice. The term was first applied by Dr. Bayford, of Lewes, to a case in which the right subclavian artery arose from the third part of the aorta, and passed to its distribution between the esophagus and trachea. This *lusus naturae* was probably a mere coincidence, since many people with these anomalies have no difficulty in swallowing."

2. Indigestion or Dyspepsia.—Epigastric discomfort, anorexia, gaseous eructations, regurgitation, nausea, fear of eating, finicky food habits, constitute a group of symptoms which we can call dyspepsia. The causes in 2,542 cases reviewed by Grier (*New England J. Med.* 224: No. 13, Mar. 27, 1941) were:

	PER CENT
Gall bladder disease	30.9
Duodenal ulcer	24.5
Functional (neurosis)	
Gastric	17.4
Colonic	7.8
Chronic gastritis	4.8
Ulcer—gastric	4.3
Carcinoma—gastric	4.0
Duodenitis	3.9
Appendicitis	3.4

Rivers and Ferreira (*J. A. M. A.* 110: No. 26, June 25, 1938) examined 10,000 patients whose primary complaint was dyspepsia. The age incidence was highest at 40-50. They found the twelve common causes were:

	PER CENT
Functional	24.7
Peptic ulcer	9.0
Cholecystic disease	8.6
Cardiovascular disease	5.6
Migraine	4.5
Constipation	3.9
Arthritis and fibrositis	3.8
Organic nervous disease	3.7
Pelvic disease	3.6
Cancer of stomach	3.0
Chronic appendicitis	2.2
Genitourinary disease	2.0

3. Hematemesis.—The term should be confined to the vomiting of approximately a pint or more of blood. Small amounts of blood are brought up at the end of a period of retching of any sort.

The differential diagnosis between blood that comes from the stomach and blood that comes from the lungs is not always easy to decide from the history alone. At least half the time patients cannot tell whether they have coughed up blood or vomited blood. In hemoptysis the blood often fills the mouth without any preceding or accompanying cough. All doubtful cases should have an x-ray study of the chest. A gastrointestinal roentgenogram is contraindicated in the presence of a fresh hemorrhage, but the cardinal points in the history of peptic ulcer should be sought.

There are a number of studies which report the causes of a series of cases of hematemesis. (Miller: *Pennsylvania M. J.* 32: 237, 1929; Shaw: *Clin. J.* 63: 23, 1934; Rivers and Wilbur: *J. A. M. A.* 98: 1629, 1932; Hellier: *Lancet* 2: 1271, 1932; Gutmann and Demole: *Bull. et mém. Soc. méd. d. hôp. de Paris* 48: 576, 1932.) They differ somewhat in the percentage of cases which were diagnosed. With considerable unanimity, if the cause is finally determined, the author's observations warrant the conclusion that if a series of consecutive cases of hematemesis presents itself the etiologic factors will be in about the following percentages:

	PER CENT
Peptic ulcer	75
Cancer of the stomach	15
Esophageal varix from:	
Cirrhosis of the liver,	5
Splenic anemia, or	
Hemolytic jaundice	
Miscellaneous, rare causes	5

RARE CAUSES: (1) Thrombosis of the portal vein. (2) Malignant infections—hemorrhagic measles, smallpox, or scarlet fever. (3) Hemorrhagic blood diseases—myelogenous leucemia, purpura, etc. (4) Miscellaneous—carcinoma of the esophagus, malaria, acute yellow atrophy of the liver, syphilis of the liver, cholecystitis.

Whether an ulcer is gastric or duodenal appears to make little difference, despite the natural assumption and frequently repeated statement that a gastric ulcer produces hematemesis and duodenal ulcer melena. In Gutmann's series 11 cases were duodenal and 8 were gastric. In Rivers and Wilbur's series 56 per cent were duodenal and 8 per cent were gastric.

The unproved or doubtful cases were of three classes: (1) ulcer history with negative x-ray study or operation; (2) alcoholic history with large liver, but no proved varices; (3) acute sick patients in whom if operation or autopsy was done nothing but a congested or hemorrhagic gastric mucosa was found. Just how large this group will be will depend on circumstances. Shaw very properly points out that Rivers and Wilbur's experience was at the Mayo Clinic and was very different from Gutmann's and his own, whose experience was in the wards of a large city hospital. Seven per cent of Rivers and Wilbur's cases were unproved, while 76 per cent of Gutmann's and 39 per cent of Shaw's were so classified. Besides, Gutmann's and Shaw's series included patients in whom at any time during their stay in the hospital vomiting of blood occurred, while Rivers and Wilbur's series were in-patients in whom hematemesis was the presenting and most important symptom. In the wards

of a hospital drawing patients from the slums of a great city there will be many who from alcoholic excess or infection or a combination of the two will have a congested gastric mucosa sufficient to produce gross hemorrhage.

4. **Diarrhea.**—The causes of diarrhea will vary widely, depending on geographic locations. In temperate climates Emerson and Cabot (Causes, Types and Treatment of Diarrhea, J. A. M. A. 61: 1015, 1913) found the causes in the following frequency:

Acute and chronic enteritis (terms which they admitted had no meaning and included food poisoning and miscellaneous digestive upsets) accounted for two-thirds of all cases.

	PER CENT
Cancer of the bowel	7
Pernicious anemia	6
Mucous colitis	5
Exophthalmic goiter	4
Neurosis	3
Tuberculosis of the bowel	2
Amebic dysentery	2
Fat intolerance	1

Fatal diseases associated with diarrhea were found at autopsy to be enteritis (unknown cause), cancer of the bowel, tuberculosis of the bowel, tuberculosis of the lung (bowel not involved).

A. *Mucous colitis* is associated with organic disease in about 17 per cent of instances. The diseases found by White and Jones in a consecutive series of patients at the Massachusetts General Hospital were appendicitis, peptic ulcer, cancer of the stomach, and Addison's disease (Ann. Int. Med. 14: 854, 1940). While most of the patients are tense and with or without reason anxious or nonsocial, it can hardly be classed as a neurosis. Perhaps psychosomatic is the word for mucous colitis. The periodical passage of masses of thick, tenacious mucus certainly indicates a functional disorder that has gone over from a neurosis into a somatic disturbance, no matter how neurotic the patient may be. "The syndrome of mucous colitis is sufficiently clear for accurate diagnosis in the majority of cases. In general, patients with mucous colitis suffer from constipation or diarrhea with some form of abdominal pain. In most cases the stools are small and mushy, or composed of hard pellets. On physical examination the sigmoid is often palpable as 'a firm rubber hose.'" (White and Jones, op. cit.)

B. *Steatorrhea.*—Fatty stools almost invariably implicate the pancreas. The fatty stool can be diagnosed by sight and smell; it is large, soft, and of foul odor. Pancreatitis (either acute or chronic), cancer of the pancreas, obstructive jaundice, caused either by cancer or gallstones, which occludes the pancreatic duct, are the causes of this rare condition. The only exception to this catalogue is sprue. I am not acquainted with tropical sprue. In temperate climates there exists a disease which has been called nontropical sprue. It is characterized by an enormous colon and periodical attacks of steatorrhea, with simultaneous distention and apparent ileus of the colon. The nature of the condition is probably a Hirschsprung's disease which did not follow the usual order of events by terminating fatally in infancy and carried over into adult

life an enormous and muscularly weak colon. The stools, when the diarrhea occurs, are fatty, but in the very few cases I have been privileged to examine, laboratory tests did not substantiate the idea that pancreatitis was present.

5. Constipation.—An abrupt change in bowel habits from regularity to constipation in a person over forty years of age indicates carcinoma of the colon. Other than this and lead colic, constipation has no diagnostic significance.

6. Flatulence.—Belching, the passage of flatus, gaseous distention, while in general normal conditions, may at times become sufficiently annoying to bring a patient to seek medical advice. A medical investigator experimenting on himself found that he evacuated a quart of gas a day—10 per cent carbon dioxide, 1 per cent oxygen, 30 per cent marsh gas, and 59 per cent nitrogen. Young, healthy college students, under experimental conditions, excrete a pint in twenty-four hours.

Medical authorities universally assert that this gas is not the result of fermentation of food, but that stomach gas is swallowed air, and intestinal gas is absorbed from the circulating blood. Whether this is true or not, I have no means of knowing.

Flatulence is seldom of any diagnostic significance. Gall bladder disease is often associated with flatulence, although the reason is not clear. Addison's disease, sprue, celiac disease, pancreatitis, and paralytic ileus are suggested by this symptom.

7. Jaundice occurs when over 4 units of bilirubin are present in the circulating blood by the van den Bergh test (about 2 mg. per 100 c.c.). It is classified into hepatogenous (obstructive, infectious, toxic) and hematogenous (hemolytic). Hepatogenous jaundice is due to bile which has been forced by pressure or has for other causes moved from the bile ducts into the blood stream; hematogenous jaundice is due to the presence of pigment formed from the hemolysis of red blood cells in the vessels.

The depth of jaundice varies greatly and may be of diagnostic value. The deepening metallic green sheen of jaundiced skin due to carcinoma at the head of the pancreas is of itself diagnostic. Very slight jaundice, so little as to be doubtful or debatable in the skin, can be seen in the edges of the sclera and—the final court—under the tongue along the frenum.

A. OBSTRUCTIVE JAUNDICE.—Jaundice from gallstones is by the nature of the case likely to be transitory. A small stone traversing the common duct will do it. A large stone forming a ball-valve mechanism gives alternate jaundice and sudden letup of both pain and jaundice as the stone is floated up from the outlet. Inspissated bile and mucus may possibly cause obstructive jaundice.

Carcinoma of the bile ducts or ampulla of Vater produces jaundice early which is progressive and usually goes on to the syndrome of complete obstruction, manifested by clay-colored stools, a fecal urobilinogen of less than 5 mg., a characteristic metallic jaundice, deeply colored urine with 0.3 mg. of urobilinogen a day. The icteric index is over 100 in completely developed cases.

B. INFECTIOUS JAUNDICE.—In White's list of the causes of jaundice (vide infra), 142 are ascribed to "acute infectious jaundice" and "acute toxic hepatitis." These constitute a third of the entire list. White listed only hospital

cases. In ambulatory practice the condition of "acute epidemic jaundice," or "acute catarrhal jaundice," represents nearly 90 per cent of any series of consecutive cases of jaundice which the general practitioner sees. .

Clinically these cases are likely to occur in epidemic form, particularly in the spring and summer, and largely affect young adults. There is a prodromal period of fever, nausea, anorexia and weakness, possibly a chill and vomiting: this lasts from three or four days to a week, and during this time the diagnosis is likely to be in doubt, especially if no epidemic is known in the community. Then the jaundice appears and the diagnosis is clear. From now on except for the jaundice the condition is usually asymptomatic. The duration of the jaundice is about six weeks: in my experience nonsurgical biliary drainage shortens this.

Now what shall we call this very frequently encountered form of jaundice? The question of nomenclature is very confused at present and should be settled. A. Weil, of Heidelberg, described (*Deutsches Arch. f. klin. Med.* 39: 209-232, 1886) four cases of "A Peculiar Acute Infectious Disease Accompanied by Enlargement of the Spleen, Jaundice, and Nephritis." All of the patients recovered; all were males—three were twenty-three years old, one was twenty-two years old. Weil's summary is as follows:

"In all four cases we were dealing with an acute febrile disease that was accompanied by severe nervous phenomena with enlargement of the spleen and liver, icterus and nephritic symptoms, but which after a relatively short duration of the severe symptoms, followed a rapidly favorable course."

This description seems as close to what I have outlined above as "acute catarrhal jaundice" as could well be. For the same reason that Allbutt (see page 13) favored the name "Graves' disease" for that syndrome, it would seem advisable to call this "Weil's disease." In fact, it is so called and understood in common clinical parlance. Allbutt (see p. 13) preferred "Graves' disease" because it did not commit one to anything: "hyperthyroidism" is inaccurate because it is not due simply to an increase of thyroid secretion: it is more likely to be a dysfunction, the appearance of an entirely strange secretion: nobody has ever produced the syndrome by feeding thyroid extract: "exophthalmic goiter" is inaccurate because it may be present without exophthalmos and without goiter. So "Graves' disease" is, according to Allbutt, the most scientific and accurate term in the present state of our knowledge (I suppose he would have accepted "Basedow's disease").

But—it is quite a but—Sailer, so far as I know ("Leptospirosis ictero-hemorrhagica [Weil's disease]" *Am. J. M. Sc.* 170: No. 3, Sept., 1925), was the first to confuse the situation by trying to be extrascientific, and ascribing the cause of Weil's disease to a *Leptospira* infection. *Leptospira* is found in the feces of 10 per cent of adult gray rats trapped in rural or urban communities in this country. The rats contaminate grain and stagnant water, this being the means of infection. The portal of entry is usually an abrasion on the skin; fish cleaners, miners, sewer workers, sugar cane cutters, and workers in rice fields are the most frequent victims. The mortality in different epidemics is 4 to 48 per cent. There is some discussion as to whether the essential pathology

is acholangitis or hepatitis. There is never obstruction of the bile passages to account for the jaundice. White and Prevost (Ann. Int. Med. 15: No. 2, Aug., 1941) reported autopsies in which the lining of the gall bladder was completely denuded, "except for an occasional group of necrotic epithelial cells." They did not find much liver cell necrosis. The liver is never shrunken as in acute yellow atrophy. Capillary hemorrhages throughout the body are commonly found. The kidneys show swelling and necrosis of the epithelium.

Now, why in the name of all the Gods against Confusion, should this be called Weil's disease? It so stands in one of the well-known books on the practice of medicine. None of Weil's cases died. One occurred in a physician, one in a merchant, and one in a waiter. We are told that *Leptospira* infection causes renal failure. Weil's renal failure was albuminuria and casts. In the same book there is another article on "Catarrhal Jaundice." Why shouldn't that be labelled "Weil's disease"? At any rate here and elsewhere in this text "*Leptospira* jaundice" will be so designated, and Weil's disease will refer to the common "acute infectious catarrhal epidemic jaundice," although so far as I am concerned I would just as soon call it, as the scientists at the corner drugstore do, yellow jaundice.

Yellow fever, malaria, amebic infection with liver abscess, syphilis (paroxysmal hemoglobinuria) are among the infections especially likely to be associated with jaundice. The mechanism is probably largely hemolysis.

C. HEPATOGENOUS JAUNDICE.—*Acute yellow atrophy of the liver* is, according to my definition, a clinical entity. That is I do not classify liver atrophies due to phosphorus or arsphenamine or any known agent with the condition I mean when I say "*acute yellow atrophy of the liver*." The etiology is unknown. It comes on abruptly with jaundice at the very beginning. One of my patients noticed his yellow hue one morning as he was brushing his hair. Three days later he was dead. Vomiting, prostration, convulsions, delirium, and all symptoms of a severe toxemia are part of the clinical picture.

Hepatic necrosis with jaundice results from phosphorus, chloroform, arsphenamine, the sulfonamides, and many other chemicals and drugs.

Cirrhosis of the liver of Laennec's type produces a jaundice—never very severe—in the terminal stages.

Jaundice occurs in 50 per cent of cases of primary carcinoma of the liver.

Syphilis of the liver causes jaundice.

D. HEMATOGENOUS JAUNDICE.

(1) *Hemolytic jaundice, acholuric hemolytic icterus*, is characterized by recurrent periods of jaundice beginning in childhood. There is enlargement of the liver and spleen. Blood examination shows a peculiar spherical shape of the red cells with increased fragility during an attack. The stools are not clay-colored. The van den Bergh test is indirect. Icterus index is high. The attacks of jaundice are considered to be due to periods when there is greatly increased destruction of the red cells and the discoloration comes from blood pigment. It is familial and hereditary, the shape of the red cell being a dominant Mendelian character.

(2) *Icterus neonatorum* is a form of hemolysis. Severe and fatal cases of jaundice of the newborn are due to other underlying pathology, such as syphilis of the liver or suppurative phlebitis of the umbilical vein.

E. JAUNDICE AS A COMPLICATION OF HEART FAILURE.—The sudden appearance of jaundice in patients with chronic myocardial difficulty should make one suspect pulmonary infarct as a cause even when there are no local signs (Keefer and Resnik: *J. Clin. Investigation* 2: 375, 1926).

In agreement with most internists whom I know well, I hold laboratory procedures which are supposed to assist in the diagnosis of jaundice in profound contempt. The only important laboratory test in jaundice is the determination of whether there is bile in the stool or not. I cannot recall any case where either the van den Bergh test, the icterus index, or any functional test of the liver helped the diagnosis in the slightest. The following tests, however, are suggested as necessary or desirable for a complete record in a patient with jaundice:

- (1) Measures of disturbed metabolism or excretion of bile pigments:
 - a. Determination of serum bilirubin or icteric index.
 - b. van den Bergh reaction.
 - c. Qualitative tests for bile pigments in urine and stool.
- (2) Measures of the capacity of the liver to perform certain functions:
 - a. To excrete into the bile endogenous bile pigments (the bilirubin tolerance test) or exogenous dyestuffs (the bromsulfalein retention tests).
 - b. To utilize certain carbohydrates (galactose tolerance test).
 - c. To detoxify or metabolize selected compounds by conjugation with substances formed by the liver (the hippuric acid excretion test).
 - d. To elaborate such substances as prothrombin, serum albumin, and cholesterol esters.
- (3) Measures of the formation of certain abnormal substances:
 - a. Determination of serum globulins
 - b. Takata-Ara test.
 - c. Cephalin flocculation test.

White ("A Study of Errors in the Diagnosis of Jaundice," *New England J. Med.* 229: 997, Dec. 30, 1943) reported on 175 cases of jaundice which came to operation or autopsy: there were errors of diagnosis in 14 (8 per cent). The commonest mistake was the diagnosis of cirrhosis in an alcoholic with deepening jaundice when cancer was actually present.

It is always worth while to do an exploratory laparotomy in a suspected case of carcinoma of the ampulla of Vater with complete obstructive jaundice, because in a certain proportion of such cases gallstones or putty-like bile at the ampulla is causing the obstruction.

Serious errors in diagnosis of jaundice were typified by a patient with acute hepatitis who was operated on for gallstones and died of bronchopneumonia and was found to have a healing subacute yellow atrophy. "We have had several opportunities since then to restrain surgeons from exploring other patients at

an early stage of the disease." Jaundice is not a surgical emergency. "The determination of the cause of jaundice in the first day or two of the disease is not essential. A good rule in acute deep jaundice with brown stools is to avoid surgical treatment. The disease is obviously not due to external obstruction, but chiefly or entirely to damage of the liver cells (acute hepatitis, cirrhosis with necrosis, etc.). The risk of operating for severe or acute diffuse hepatitis at the height of the jaundice is extremely great. This is seen when the mortality of ordinary gall bladder operations, from 2 to 5 per cent, is compared with that of about 35 per cent in operations on cirrhosis and with nearly 100 per cent in operations on cases of acute yellow atrophy or severe acute hepatitis. In chronic cases there is no reason to hurry a difficult diagnosis. Most patients with obstruction due to stone preserve liver function for a long time." (White.)

Ease of Diagnosis.—The easiest cases to diagnose in White's experience were toxic hepatitis in which there was an exposure to chemicals or drugs. Next easiest was complete obstruction, determined by absence of bile in the stool and complete absence of urobilinogen from the urine on repeated tests. All but one of such cases proved to be cancer. Hemolytic jaundice in chronic familial cases had so many characteristic features that diagnosis was easy. The diagnosis of gall bladder disease with modern methods—history, physical examination, Graham-Cole test, biliary drainage, etc.—is relatively easy.

Relative Incidence of the Causes of Jaundice.—

In White's series (500 cases, 175 proved) the following percentages obtained:

		TOTAL CASES	PER CENT
Complete external obstruction		33	6.6
Cancer pancreas	24		
Cancer common duct	6		
Cancer hepatic duct	2		
Stone in common duct	1		
Partial external obstruction		93	18.6
Gallstones	71		
Stricture common duct	5		
Acute pancreatitis	4		
Cancer bile ducts or pancreas	5		
Cholangitis and abscess	8		
Hepatocellular jaundice		359	71.8
Acute infectious hepatitis	101		
Acute toxic hepatitis	41		
Cirrhosis	161		
Portal	127		
Biliary	9		
Pigment	7		
Toxic	12		
Banti	3		
Cardiac	3		
Fatty liver	9		
Tumor of liver	46		
Syphilis of liver	1		
Hemolytic jaundice		15	3.0

8. Acute intestinal obstruction is caused by intussusception, volvulus, postoperative adhesions, strangulated hernia, paralytic ileus, hemorrhage or edema of a neoplasm, and Hirschsprung's disease.

9. *Melena*—blood in the stool. When fresh and bright red and adherent to the surface of the stool, blood comes in most cases from internal piles, fissure, or rectal ulcer. Blood mixed with the stool and partially digested, dark (black) in color and tarry, comes from bleeding high up in the digestive tract and is due to peptic ulcer, cirrhosis of the liver, gastric carcinoma. Bleeding from an ulceration lower down or in the colon in amebic dysentery, typhoid ulcer, ulcerative colitis, tuberculous enteritis, is usually profuse and likely to be unclotted and not mixed with the stool.

VIII. SYMPTOMS REFERABLE TO DISEASE OF THE URINARY TRACT

1. *Polyuria*.—This symptom must be analyzed so that a distinction is made between frequency of micturition and actual increase in the 24-hour excretion of urine (real polyuria). Naturally they are often associated.

The normal adult bladder holds about 300 c.c. of fluid when slightly distended; 200 to 250 c.c. distends it sufficiently to call out the desire for emptying it.

The 24-hour amount of urine will vary with individual habits of liquid intake, but is generally considered around 1,200 to 1,500 c.c.

Frequency of micturition alone is commonly caused by pregnancy, gonorrheal urethritis, neurosis, and prostatic hypertrophy. All other causes are comparatively uncommon: they are uterine fibromyomata, stone in the bladder, tumor of the bladder, and tuberculosis of the urinary tract.

Intermittent polyuria with frequency of micturition occurs in floating kidney after a Dietl's crisis and in the condition known as intermittent hydro-nephrosis. The diuresis which precedes an attack of gout and which is independent of thirst or increased intake of fluid is well known to all sufferers from that disease.

Polyuria is commonly caused by diabetes mellitus and chronic nephritis. Rare causes are diabetes insipidus and congenital polycystic kidneys.

The polyuria of nephritis develops in an orderly manner with the progress of the disease. It may be roughly estimated by the progress of nocturia. A normal young adult who does not take in any more fluid after the evening meal than a glass of water at bedtime and who empties the bladder before going to bed sleeps through until morning with no emission of urine. The nephritic, because the kidneys cannot concentrate urinary excretory products rapidly, spaces the excretion more evenly over the twenty-four hours and begins to have nocturia, arising first six or seven hours after retiring, and later arising twice, still later, three or four times a night. Barring unusual fluid intake between the evening meal and bedtime, the night urine should average 450 c.c., should never exceed 750 c.c., and should never be more than 75 per cent of the day urine.

As nocturia increases in nephritis and the kidneys tend to space urinary excretion evenly over the twenty-four-hour period, the specific gravity of each specimen falls.

2. Diminished Urinary Output.—Oliguria and anuria occur in *acute nephritis*, such as occurs in scarlet fever and mercury poisoning, *nephrosis uremia*, *the kidney of pregnancy* and *eclampsia*, *congestive heart failure*, distention of the stomach, paralytic ileus, excessive enuresis, and any condition of dehydration.

3. Retention, Incontinence, Frequency, Urgency of Urination.—Aside from enuresis, these symptoms practically invariably come either from urethral stricture, prostatic disease, or neurogenic bladder.

The neurogenic bladder can be understood only in the light of a knowledge of the physiology of micturition. "The bladder is made up of smooth or involuntary musculature. The detrusor muscle, which expels fluid from the bladder, merges insensibly into the musculature of the bladder neck, which forms the internal sphincter. The two muscles, detrusor and sphincter, receive their nerve supply by way of the pelvic nerves, derived from the second and third sacral segments, and their common nerve supply is reflected by the fact that they act in unison, the sphincter relaxing as the detrusor contracts, and vice versa.

"Such coordinated activity makes implicit a neural organization. Sensory data on the state of muscle stretch must be carried to the central nervous system, and motor activity must be initiated over the motor pathways. . .

"The external sphincter serves an auxiliary purpose; it is made up of striated or 'voluntary' muscle and its central motor connections also lie in the second and third sacral segments, but the cells of the anterior horn lie in that portion of the gray matter which has to do with the somatic, as opposed to the parasympathetic, system, thus making these centers subject to a greater degree to the control of the will.

"The external sphincter is at most times kept in a constant state of 'tone' or closure by a steady stream of nerve impulses transmitted from these centers downward to the sphincter by way of the pudendal nerves. Relaxation of the sphincter occurs only when these impulses cease to arrive at the muscle; at such times urine can pass by the sphincter, the passage being abruptly cut off when a resumption of the nervous discharge occurs." (Evans: *J. A. M. A.* 117: 1927, 1941. See Langworthy, Kolb and Lewis: *Physiology of Micturition*, Baltimore, 1940, Williams & Wilkins Company.)

Any interference with this nerve supply results in the neurogenic bladder. Commonly it occurs in *tabes dorsalis*, destructive (usually traumatic) lesions of the *cauda equina* or *conus terminalis*, and complete transverse lesions of the spinal cord above the cauda. Rarely lesions of the paracentral lobule of the cerebrum result in loss of bladder control.

4. Hematuria.—Blood in the urine in a series of 860 cases where this was the presenting symptom was found by Kretschmer to be due to:

	PER CENT
Tumor of the genitourinary tract	76.5
Papilloma or carcinoma of the bladder	
Hypernephroma	
Stone	5.8
Tuberculosis	4.1
Miscellaneous	11.2
General disease	1.0
Cause undetermined	1.4

In 96 per cent of cases of hematuria the cause of the bleeding was found within the genitourinary tract. Associated symptoms (in order of frequency) were pain, frequency, pus, burning, passing clots, retention, fever, vomiting and nausea, chills, casts, tubercle bacilli. (Surg., Gynec., Obst. 40: 683, 1925.)

In 1,500 admissions to the genitourinary service of Brooklyn Hospital hematuria was the outstanding symptom in 13.5 per cent of cases. (Rathbun: J. Urol. 30: 15, 1935.)

Of 2,240 cases of *gross* hematuria admitted to the department of Royal Victoria Hospital, the sources of bleeding were:

	PER CENT
Kidney	41.38
Ureter	12.23
Bladder	20.80
Prostate	17.90
Urethra	5.53
Unclassified	2.14

Mackenzie (Canad. M. A. J. 27: 405, 1932), who collected this report, comments: "In plain terms of the 2,440 cases treated, approximately 75 per cent were due to these grave conditions. Surely this cannot fail to impress us with the fact that red blood cells have no place in the normal urine, and that they are caused by some pathologic condition which it is our duty to discover."

General conditions which cause hematuria are: (1) the blood dyscrasias: hemophilia, polycythemia, purpura and myelogenous leucemia; (2) acute infections: scarlet fever, measles, tonsillitis, smallpox and malaria; (3) deficiency and dietary disease: scurvy and high protein diet; (4) following medication: urotropin, cantharides, turpentine, sodium salicylate, mandelic acid, sulfonamides.

In most of these the hematuria is minimal and found only on centrifugation or by microscope.

Blood cells in the urine of *acute nephritis* are of serious prognostic import.

There is a form of gross hematuria which the urologists deny exists—essential hematuria. I have seen enough cases to describe it in the following terms. An adult suddenly painlessly passes a specimen of urine that is so full of blood cells it assumes the appearance of blood in a physiologic salt solution. A complete and careful examination fails to reveal any cause for it. There is little disturbance of general health. In a few days the urine is clear. The patient goes on without operation of any kind and lives indefinitely—one I know is alive and well fifteen years, one, nearly twenty years after the occurrence. On one occasion in a patient of mine the blood was found coming from only one ureter. An operation was performed and the kidney on that side removed. In the most painstaking examination, except for a small bleeding point in the lip of a calyx, not a single pathologic lesion was found.

IX. SYMPTOMS REFERABLE TO THE CIRCULATORY- RESPIRATORY SYSTEM

A. Dyspnea.—Dyspnea is difficult or labored breathing. The "dys" part of the word indicates that the act of respiration is obtruded into consciousness.

Rapid respirations—hyperpnea, such as that of acidosis, or irregular respiration, such as Biot's breathing or Cheyne-Stokes breathing, can and usually do occur in the unconscious state and are not necessarily included in the term dyspnea. They are considered on pp. 174 and 175.

Inhalation and exhalation are stopped and started by afferent impulses from the lung parenchyma described in 1868 by Hering and Breuer. They showed that inflation of the lungs arrested inspiration, expiration then ensuing, while deflation of the lungs in turn arrested expiration. This is known as the Hering-Breuer reflex.

The cause of dyspnea is related to the normal stimulus to respiration which Haldane and Priestly showed experimentally in 1905 to be carbon dioxide in the blood acting upon the respiratory center which is extremely sensitive to the accumulation of carbon dioxide, so much so that a rise of 0.2 per cent in the carbon dioxide content of the alveolar air will cause a rise of 50 per cent in the amount of air respired. Following Haldane and Priestly's work, it was shown that the center is equally sensitive not only to carbon dioxide but to any acid radicals in the blood.

Any increase in metabolism naturally tends to increase the accumulation of carbon dioxide and hence the rate of respiration. Thus Peabody and his co-workers found that an experimental subject exercising upon a stationary bicycle and breathing into a ventilator which allowed of the expired air being measured, raised the amount of air expired from about 5 liters a minute while at rest to about 50 liters a minute when exercising to the limit of capacity. Ordinary walking about raised the minute-volume of air three times.

Interpreting this in terms of physiology, it means that an increase in oxygen consumption by the cells of the body and the simultaneous increase in the production of carbon dioxide causes an accumulation of carbon dioxide in the blood. This arriving at the respiratory center stimulates it to activity and results in an increase in the rate and depth of respiration, or in other words in the minute-volume of respiration. This increase in ventilation, however, is useless unless an increased amount of blood flows through the lung and after aeration is carried to the tissues.

Thus in a series of experiments on men doing an increasing amount of work, Boothby found *that there was a strict parallelism between the time volume of the blood flow, the time volume of the ventilation, and the oxygen consumption per unit of time.*

Dyspnea may be due to many physiologic and pathologic changes:

1. Metabolism—increase in the rate of oxidation, with increase of acid bodies in the blood.
2. Respiratory—reduction of lung volume; i.e., from fluid in the pleural cavity, or reduction in the elasticity of the alveolar wall, from emphysema or atelectasis.
3. Blood composition—reduction of oxygen-carrying bodies, as in anemia.
4. Cardiac—reduction of the rate of blood flow through the lungs.

In a series of clinical cases in which dyspnea was the prominent or presenting symptom the pathologic causes were found to be in the following proportion:

	PER CENT
Heart failure of the congestive type	48
Phthisis	25
Emphysema, asthma, chronic bronchitis and pneumoconiosis	14
Pneumonia	9
Arteriosclerosis, aortitis, angina pectoris, nephritis	3
Pleural fluid	1

Infiltration of any considerable extent in the walls of the alveoli of the lung will produce dyspnea as a prominent sign. Silicosis is an example, in which the most distressing symptom is dyspnea.

Emphysema produces dyspnea partly on account of the lung pathology and partly on account of the accompanying heart condition—cor pulmonale.

Obscure tracheal obstructions may be a source of puzzling dyspnea, puzzling because the source is not at once obvious, for instance, substernal goiter.

Aortitis is especially likely to cause paroxysmal dyspnea. In syphilitic aortitis with aortic insufficiency it is very often the first and continues to be the most troublesome sign. Keefer the Resnik (Paroxysmal Dyspnea as a Symptom of Syphilitic Aortitis, Arch. Int. Med. 37: No. 1, Feb., 1926) found that it is practically never associated with rheumatic aortic insufficiency, so the relationship must depend largely on the inelasticity of the aorta. They also noted, however, that it occurred most frequently not in aortitis alone, but in aortitis complicated by aortic insufficiency, or hypertension.

Nephritic dyspnea is probably more dependent on the arteriosclerosis, hypertension, and aortitis than on the nephritis itself. Prostatism markedly augments nephritic dyspnea.

In the hyperpnea of diabetic acidosis the respirations are full and deep, likely to be slow or gasping. As a point of valuable differential diagnostic value the respirations of insulin coma are rapid and shallow.

No more delicate test of the functional capacity of the myocardium could possibly be devised by the most skillful physiologic artisan than the amount and degree of dyspnea. From the early chapter in which the patient tells you he can no longer run for a street car, through the episodes when he cannot walk rapidly or climb stairs without shortness of breath, through the period of the increasing number of pillows he requires at night, to the time when he must always sit erect, or finally when even the erect position becomes a burden and he must lean his tired forehead on a rest, the record of the gradually exhausting myocardium is written in the finest and most exact Italian script.

Dyspnea at rest has been well classified by Harrison, Calhoun and Harrison (Arch. Int. Med. 53: 561, 1934):

1. ORTHOPNEA is difficulty in breathing in the recumbent position. Dorland's dictionary defines it as *inability* to breathe in the recumbent position.

It is not, at first analysis, a symptom easy to explain. One would think it would be easier for the heart to maintain the circulation when all the blood

channels are on the same level as the heart itself, and there is no gravitation to overcome.

The earlier writers believed the sitting posture is assumed because the accessory muscles of respiration could then be used to greater advantage. Hofbauer (*Ursachen der Orthopnoe. Ztschr. f. klin. Med.* 61: 389, 1907), however, believed the principal difficulty was expiratory, and thought the orthopneic position secured the mechanical advantages of a lower position of the diaphragm, a consequent increased capacity of the thorax which allowed greater elastic tension of the alveoli. Aron (*Virchows Arch. f. path. Anat.* 126: 517, 1891) showed that the upright position increases the negative intrathoracic pressure and thus aids the right ventricle in maintaining blood flow through the lungs. Christie and Beams (*The Estimation of Normal Vital Capacity With Especial Reference to the Effect of Posture. Arch. Int. Med.* 30: 34, 1922) reported that the average vital capacity of the lungs of 290 normal persons while lying down was 5.5 per cent less than while sitting. Nine patients with orthopnea, with an average reduction of 69.5 per cent from the estimated normal vital capacity, lost an additional 26.7 per cent on lying down. Bohr (*Deutsches Arch. f. klin. Med.* 88: 385, 1907) found a decrease in the vital capacity, reserve air, and middle capacity of the lungs and an increase in the complemental air in the recumbent as compared with the sitting posture. Haldane, Meakins, and Priestly (*J. Physiol.* 52: 433, 1919) showed that even in healthy persons the recumbent position accentuates the unevenness with which the lungs normally expand and so tends to produce anoxemia.

Doubtless all of these mechanical factors play an important part in the physiology of orthopnea, but the action of the respiratory center must also be taken into account, as pointed out by Ernestine and Blumgart (*Orthopnea, Arch. Int. Med.* 45: No. 4, 1930) and in an excellent review of the literature and an account of their own experimental studies:

"We believe that the orthopneic position benefits the patient with congestive circulatory failure because it secures a maximum blood flow about the respiratory center and thereby relieves the patient from the distress due to partial asphyxia in that area. The mechanism of this is conceived to be as follows: Physiologic investigations indicate that the blood flow in the capillaries is dependent on the pressure gradient in these vessels. The greater the difference in pressure along the capillary, the greater the blood flow. An elevation of the venous pressure, therefore, diminishes capillary blood flow in the absence of any striking increase in arteriolar blood pressure. Other factors remaining equal, increased venous pressure leads to stagnation of blood in the capillaries and so produces stagnation anoxemia. It is well known that in myocardial failure the peripheral venous pressure is increased roughly in proportion to the degree of decompensation.

"The orthopneic position, in our opinion, relieves the respiratory center of the increased pressure within the veins of that area in the following manner. There are no efficient valves in the veins between the cerebral capillaries and the right auricle. If a patient with uncomplicated cardiovascular failure and a venous pressure at the right auricle equivalent to 15 cm. of water lies flat in bed, there is a corresponding pressure of 15 cm. of water in the veins about the respiratory center. This results in diminished blood flow in the capillaries and stagnation anoxemia in this region. If, however, the patient

sits up, so that the respiratory center is 15 cm. above the right auricle, the pressure in the veins about the center is zero. The blood flow in the capillaries leading to these veins would then be increased, the respiratory center would receive a more adequate supply of blood, and the subjective respiratory distress would be relieved."

2. **EVENING DYSPNEA** is respiratory distress which is minimal in the morning and tends to come on gradually during the day. It is more common in cardiac failure due to hypertension, arteriosclerosis, and syphilitic aortic insufficiency.

3. **CARDIAC ASTHMA**.—Clifford Allbutt once pontifically explained that there is no such thing as cardiac asthma, and then James Mackenzie carefully showed him how to recognize it, what it is, and when it occurred. Mackenzie's description (in *Diseases of the Heart*, ed 3, 1918) of cardiac asthma was: "A form of respiratory distress which comes on usually at night, sometimes suddenly arousing the patient from sleep. An attack of this sort is sometimes the first serious sign of heart trouble. The patient may have gone to bed in his usual health and after three or four hours sleep he is awakened with a feeling of suffocation and an intense desire to breathe deeply. He sits up in bed and breathes in deep and labored fashion. Wheezing sounds may appear in the chest, and he may cough up some frothy phlegm. Once these attacks begin, they are likely to continue, and the nights of the patient often become periods of great distress. The class of case which shows this condition most characteristically is the elderly and those who suffer from arterial and coronary sclerosis. They frequently have high blood pressure."

It is evident that this is really not asthma, in spite of the wheezing. There is no bronchial spasm, no real expiratory distress. The attacks have also been called paroxysmal nocturnal dyspnea.

4. **NOCTURNAL DYSPNEA** is a little different from this description of Mackenzie's in that the respiratory center is mainly to blame. The elderly arteriosclerotic patient who must sleep on two or more pillows, slips off them in the night and gets his respiratory center clogged as in orthopnea. This wakes him up breathless, but the discomfort passes off as soon as he assumes his comfortable sleeping position.

Harrison (*Failure of the Circulation*, 1939) gives a good description of a form of periodic breathing very familiar to the clinician:

"I refer to attacks which come at the onset of sleep and almost exclusively then. Like patients with cardiac asthma, the sufferers from the second type of paroxysmal dyspnea usually have one of the disorders which cause a primary strain on the left ventricle. In some instances the patient has evening dyspnea, but often this warning symptom is absent and the subject is comfortable when he settles himself for sleep. With the onset of sleep there is a period of depressed breathing or even of apnea. This is succeeded by a mild hyperpnea, which is followed by a second and even more pronounced phase of depression. The next hyperpneic period is likely to be more pronounced, until at length, following an unusually long apneic phase, the patient awakens with a severe paroxysm of dyspnea.

"With the onset of the succeeding apnea the patient dozes again and the entire cycle repeats itself. This state of affairs may persist for several hours or even throughout the night."

Palmer and White (Clinical Significance of Cardiac Asthma, J. A. M. A. 92: No. 6, Feb. 9, 1929) found these paroxysmal dyspneic attacks (nocturnal dyspnea, or cardiac asthma) in 250 of a group of 3,100 cases of organic heart disease. They occurred in 10.7 per cent of the arteriosclerotic-hypertensive form of heart disease, in 2.2 per cent of rheumatic, and 21 per cent of syphilitic heart disease.

The condition is of grave prognosis: 70 per cent of patients died within one year three months after the first attack.

5. **DYSPNEA WITH HYDROTHORAX** deserves a separate category in the clinician's mind because he can do so much to relieve it. The encroachment of fluid in an already overburdened lung space is quite an emergency, and yet too often neglected. I remember an eminent cardiologist who had called a group of distinguished consultants, and finally asked me to see him. He was very dyspneic and thought he had a pancreatic cyst. In the presence of such a galaxy of clinical talent, I with some temerity, suggested he had ascites and hydrothorax. With obvious misgivings they consented to a tap; two quarts of fluid removed from his chest relieved his dyspnea considerably, and over a gallon from the belly dissolved the pancreatic cyst. But he had been left that way for weeks.

6. **CHEYNE-STOKES RESPIRATION** in the cardiac or arteriosclerotic patient, or Biot's breathing or periodic breathing is the best example of dyspnea due more to poor circulation in the respiratory center than to myocardial failure. But, of course, there are elements of both in all cases of Cheyne-Stokes respiration.

7. **NERVOUS DYSPNEA**.—Functional neurosis is a common cause of rapid and—what looks to superficial observation—labored breathing. It is not difficult to spot these false dyspneas, however, even without an exhaustive physical examination—just on the characteristics of the attacks themselves. They take several forms:

Hysterical.—Laryngospasm may bring on respiratory difficulties sufficiently serious to lead to asphyxia. Hysterical dyspnea, however, usually is a part of petit attack of hysteria. The patient puts on a show and runs the gamut. The dyspnea may, however, play the lead role among the symptoms in one or another of the attacks—"I am suffocating. I can't get my breath. I am dying," etc.

Emotional crises, or long-continued worry, love affairs or just plain introspection will bring on a form of dyspnea very familiar to me. The patient will almost invariably complain of a sensation of not being able to get the breath to the bottom of the lungs, of wanting and unsuccessfully trying to fill all the air spaces. To put it in medical terms, they feel so far as I can understand them, as if the alveoli at the periphery of the lungs were collapsed. So they indulge at intervals in a series of long, labored breaths, all the while looking around with the most pitiable appeal for sympathy.

Maytum and Willins (Abnormal Respiration of Functional Origin, Proc. Staff Meet., Mayo Clin. 9: 308, May 23, 1932) say:

"Two types of abnormal breathing are observed, the sighing type and the panting type. They differ chiefly in the rate of respiration and in the severity of the attack. The first type is by far the most common and although distress-

ing is usually not severe. The latter type may assume alarming proportions. Hyperpnea if continued results in hyperventilation which has been demonstrated to be capable of producing tetany."

B. Cyanosis.—Cyanosis is a bluish discoloration of the skin, mucous membranes, finger nails and toe nails, and retina. It is due to an excessive quantity of reduced hemoglobin in the peripheral capillaries, irrespective of the amount of oxyhemoglobin which may be present. It is ultimately circulatory or respiratory in origin.

The respiratory causes are any of the things which interfere with the optimum partial pressure of oxygen in the alveoli for the degree of saturation of the blood. Other things being equal, they are dependent on the partial pressure of oxygen in the alveoli. Given a normal partial pressure of 100 millimeters of mercury the blood saturation will then depend on the ready access to the blood through the alveolar membrane. All conditions being normal, the blood will become 95 per cent saturated and 5 per cent unsaturated. The unsaturation represents the uncombined or reduced hemoglobin. This 5 per cent represents about one cubic centimeter volume per cent (20 cubic centimeters per cent being full saturation). This is not enough reduced hemoglobin to produce cyanosis. Anything above this will theoretically produce cyanosis, although for practical purposes cyanosis is not evident until reduced hemoglobin in the peripheral circulation has risen to ten cubic centimeters volume per cent.

General chemical changes in the body interfering with the acid base balance may produce cyanosis. Acidosis does not, because the respiratory center is so sensitive to decrease in the pH that it results in hyperventilation of the alveoli. Alkalosis produces the opposite effect—shallow breathing which results in decline of partial pressure of oxygen and rise in reduced oxygen with cyanosis.

Atmospheric conditions of either a reduced oxygen percentage in the refined air or a normal percentage with reduced barometric pressure will result in cyanosis. The first is present in mines, called "black damp," or "choke damp." The second is found at altitudes. (See "*The Conquest of Mount Everest*, by Younghusband.)

Variations in the depth, quality, and distribution of cyanosis is important as to both diagnosis and prognosis. Increasing unsaturation results in dilatation of the capillaries and vesicles—the Bohr phenomenon. Severe anoxemia, for instance pneumonia, causes a generalized purplish discoloration, but if the anoxemia and other factors result in vasomotor collapse there is a combined discoloration, with purplish cyanosis more marked in the lips, ears, and nails, and the rest of the skin a dirty gray color, indicating impending exitus. (See Meakin's *The Practice of Medicine* page 180 for excellent colored plates of these contrasting appearances.)

The general physiologic conditions which produce cyanosis may be analyzed into five:

1. Incomplete oxygenation of the blood in the lungs.

2. A shunt which carries unaerated blood from the venous to the arterial system.

3. An increased oxygen depletion as the blood passes through the tissues, due to stasis or sluggish circulation. This is the cyanosis of heart failure.

4. Total hemoglobin content. Reduced hemoglobin does not tend to cyanosis, so in anemia it is rare. When the hemoglobin of the blood is greater than normal, a smaller percentage of hemoglobin is reduced—such is the explanation of the semicyanosis of polycythemia.

5. Abnormal forms of hemoglobin, methemoglobin and sulfhemoglobin.

Respiratory diseases are more frequent causes of cyanosis than circulatory diseases. Acute conditions are pneumonia or any form of acute pneumonitis. The chronic causes are emphysema, asthma, and chronic bronchitis and bronchiectasis. With many of such cases cor pulmonale is found accompanying the lung disease and the assessment of the relative responsibility of the respiratory and circulatory conditions in producing the dyspnea is a matter of opinion. Any fibrosis of the lung will tend to cyanosis, especially on exertion. Tracheal or laryngeal obstruction produces cyanosis—postpharyngeal abscess, diphtheria, edema of the larynx, Ludwig's angina, the laryngismus strigulus of tetany, foreign body, outside pressure from lymph nodes or thyroid, tumors of the vocal cords or glottis, laryngeal crisis of tabes, tuberculosis or syphilis of the larynx. Pneumothorax and massive hydrothorax are possible causes.

Prominent among circulatory causes are congenital heart disease, Ayerza's disease (endarteritis of the pulmonary circulation), acute congestive heart failure, although, contrary to general word of mouth preachments, cyanosis in the last condition is conspicuous for its absence.

A very remarkable syndrome was described first, I think, by Neusser (Dyspnoea and Cyanosis, by Prof. Edmund von Neusser, translated by Andrew MacFarland; E. B. Treat and Co., 1907). "Dyspnea with the most intense cyanosis of the face and neck, with positive venous hum over the aorta, with edema of the *upper half of the body*, while the lower half is unaffected, occurs in perforation of aneurysm of the aorta into the superior vena cava."

Winckel's disease is a marked cyanosis associated with jaundice and hemoglobinuria in the newborn. (Wheeling and Slesinger: Arch. Pediat. 51: 740, Nov., 1934.)

Forms of bluish discoloration of the skin, which are not cyanosis but may be mistaken for it, are: sulfmethemoglobinemia, due to prolonged excessive use of coal tar derivatives, such as acetanilid; enterogenous cyanosis, shoe dye poisoning, ochronosis, argyria and bismuth discoloration are described in the section on the skin. (See pp. 203-205.)

Edema.—The relative frequency of bilateral edema of the legs differs with the class of patients seen—ambulatory or bedfast.

In 100 cases in the wards of the Massachusetts General Hospital the causes were:

Heart failure	60
Varicose veins	10
without obesity	6
with obesity	4
Marked obesity alone	2
Renal disease	7
Nutritional	7
Cirrhosis of the liver	7
Leucemia	2
Myxedema	2
Miscellaneous	3
(includes cases of carcinoma, multiple neuritis, alcoholism; beriberi is a possibility)	

In 100 cases seen in the outpatient department of the Massachusetts General Hospital the causes were:

Varicose veins	56
without obesity	25
with obesity	31
Heart failure	13
Marked obesity alone	13
Renal disease	3
Nutritional	3
Cirrhosis of the liver	2
Miscellaneous	7
(rheumatoid arthritis, cancer of the cervix, myxedema, bilateral phlebitis)	

(See Foote, Reed, Comeau, and White: *The Clinical Significance of Bilateral Edema of the Lower Extremities*, *Am. J. M. Sc.* 199: 512, April, 1940.)

Generalized edema is due in the vast majority of cases to heart failure. This edema is progressive, always beginning in the lower legs, proceeding to ascites, hydrothorax, etc. Even so cardiac edema seldom involves the face. Nephrosis is a cause of generalized edema, but is comparatively rare. When edema comes on, involving the face primarily though not exclusively, nephrosis may be suspected. Generalized edema of nutritional origin is also rare, except, perhaps, in children.

It is difficult to evaluate nephritis as a cause of edema. (I am distinguishing nephritis from nephrosis.) Nephritis is so inevitably intertwined with arterial and cardiac changes that when edema occurs one does not know just when the mechanical factors leave off and the chemical factors begin.

The generalized edema of the toxemia of late pregnancy may be one of the classic triad of signs of that condition—hypertension, albuminuria, and edema. It may be the first manifestation. A weight gain of more than one pound a week during late pregnancy is suggestive; a gain of three pounds is definitely pathologic. The patient may store ten pounds of water before exhibiting clinical edema.

Menstrual edema is quite common. Sweeney (*J. A. M. A.* 103: 234, July 28, 1934) found that of forty-two normal, healthy young women whose weight was recorded before, during, and after menstruation, approximately 30 per

cent showed a gain of three or more pounds sometime during the menstrual cycle, usually just before the period was established. Some cases showed a true pitting edema. Thorn, Nelson, and Thorn (*Endocrinology* 22: 155, 1938) present a study of its mechanism.

The basic physiology of edema depends upon the operation of one or more of these factors:

1. Increased permeability of the capillary wall (snake venom, asphyxia, anoxemia, burns, allergy, urticaria).

2. Decreased osmotic pressure of the blood, as after plasmapheresis and repeated hemorrhages, and in cases of massive albuminuria (Hypoproteinemia). The thinner fluid is drawn into the tissues. Nutritional edema is of this type. Perhaps nephrosis also.

3. Increased intracapillary hydrostatic pressure in the vessels of the region involved (cardiac failure, varicose veins).

4. Retention of substances in the blood, the accumulation of which disturbs the normal osmotic relationship between the blood plasma and the tissues.

"In cardiac or circulatory edema disturbance of intracapillary hydrostatic pressure is the prime factor in the mechanism of the edema, but in addition there is change in the permeability of the capillary wall related to anoxemia and other causes, slight change in electrolytic pattern, slight change in hydrogen ion concentration, slight change in water content, all, of course, increased if there is an accompanying renal disturbance or anemia." (Christian.)

The edema of nephrosis is dependent upon a wide disturbance of body chemistry. The blood shows a hypoproteinemia with a reversal of the normal albumin-globulin ratio (normally 1.5 to 2.5:1). The plasma globulin is increased, upsetting this ratio. The blood cholesterol, fatty acids, and phosphatids are greatly increased. Loss of albumin by albuminuria is constant. There is a marked reduction of sodium chloride in the urine during the anasarca, and an increased elimination as the anasarca subsides, although the plasma chloride is not usually markedly disturbed.

Amyloid disease is now a rare condition, but in widespread neglected tuberculosis and sepsis of long standing, it must be remembered as a cause of anasarca.

The edema of hypothyroidism is of a unique type. It is due to an increase in the nucleoprotein of the intercellular regions, the architectural skeleton that holds the cells together. As a result of this increase in protein in tissue fluid, salt and water are retained, with the resulting myxedema.

The influence of the ductless glands on water balance is the basic factor in the causation of the edema which may occur in their disturbances. (See Thorn and Emerson: *The Role of Gonadal and Adrenal Cortical Hormones in the Production of Edema*, *Ann. Int. Med.* 14: 757, 1940.)

Palpitation of the heart is consciousness of the beating of the heart. This definition indicates that two elements are involved: the heart, the originator of the symptoms, and consciousness, the receptor. Every experienced clinician knows that in cases of palpitation the receptor is more often at fault than the

originator. Potain expressed the extreme statement of this view in the aphorism—"Tout malade qui consulte pour les palpitations doit être présumé exempt de maladie de coeur."

Baker (*Lancet* 231: 787, Oct. 3, 1936) found 163 out of 1,004 consecutive patients at the Outpatient Department of the National Hospital for Diseases of the Heart to have the chief and presenting complaint of palpitation. Of these 74 (45 per cent) were found to be entirely free of any abnormal cardiovascular condition.

Of the 89 patients with organic circulatory disturbance, 21 had thyrotoxicosis, 24 had hypertension, 23 had paroxysmal tachycardia, 21 had rheumatic heart disease, and in 7 the causes were miscellaneous.

The conditions found in those complaining of palpitation with no organic heart disease were in order of frequency: indigestion (again recalling Potain—"Toutes les fois qu'un malade se plaint du coeur, recherchez l'état de son estomac et son intestin."), obesity, debility following illness, menopause, tea, tobacco, fatigue, neurocirculatory asthenia, anxiety, infective foci.

Surprisingly to me, Dr. Baker states categorically that extrasystoles or aortic regurgitation are seldom associated with palpitation.

Children never have, or at least never complain of, the symptom.

Gilechrist (*The Practitioner* 146: No. 874, April, 1941) records the study of 36 patients complaining of palpitation as follows:

ETIOLOGY OF THE UNDERLYING DISEASE	RHYTHM DURING PALPITATION								M	F	TOTAL
	NORMAL RHYTHM	EXTRA- SYSTOLES	PAROXYSMAL FIBRILLATION	PAROXYSMAL VENTRICULAR TACHYCARDIA	ESTABLISHED AURICULAR FIBRILLATION	AURICULAR FLUTTER	PAROXYSMAL AURICULAR TACHYCARDIA				
None (imaginary)	6	3	0	0	0	0	0	3	6	9	
Hypertension and and/or arteriosclerosis	2	3	0	0	0	0	1	3	3	6	
Thyrotoxicosis	2	1	2	0	0	0	0	0	5	5	
Rheumatism	0	0	2	0	2	0	1	0	5	5	
Unknown cause	0	0	1	1	0	2	0	1	4	5	
Coronary thrombosis	0	0	0	3	0	0	0	3	0	3	
Syphilitic aortitis with regurgitation	0	2	0	0	0	0	0	0	2	2	
Emphysema	0	1	0	0	0	0	0	1	0	1	
Congenital defect	1	0	0	0	0	0	0	0	1	1	
Totals	11	10	5	4	2	2	2	11	26	37	

Angina Pectoris.—The syndrome of angina pectoris may be described thus:

An individual around fifty years old has a sudden (initial) attack of pain, related to effort in about 50 per cent of cases. The pain is localized under the sternum, but may be anywhere in the precordium and may radiate or initiate in the epigastrium, up the sides of the neck, or down the arms. It is of gradually increasing intensity, viselike in character. It imposes immobility. It may cause vomiting. It may or may not be accompanied by evident arterial change, cardiac enlargement, dyspnea, elevation of blood pressure, fever or leucocytosis.

This syndrome is so characteristic that it nearly always means spasm of a sclerotic coronary artery or thrombosis of a coronary artery. The question arises what other diseases can cause an imitation of this syndrome and how proportionately frequent are they?

Harrison (Some Puzzling Aspects of Pain in the Chest, J. A. M. A. 120: 519, Oct. 17, 1942) lists the following:

1. Myalgia and arthralgia in the region of the left shoulder.
2. Spinal arthritis—radicular pain of sudden exacerbation.
3. Pericarditis.
4. Mediastinal lymphadenitis.
5. Penetrating diseases of the aorta—dissecting aneurysm, ruptured syphilitic aneurysm, syphilitic aortitis.
6. Duodenal ulcer.
7. Pylorospasm due to gall bladder disease.
8. Cascade stomach.
9. Diverticulum of the stomach.
10. Dextrose deficiency with insulin shock.

Wolferth and Edeikin (The Differential Diagnosis of Angina Pectoris, Pennsylvania M. J. 45: 579, March, 1942) emphasize esophageal spasm as an imitation of angina pectoris. They recall the theory of Verdou and of Jackson that the pain of what we call angina pectoris is in reality produced by spasmodic contractions of the esophagus and stomach. Morrison and Swalm (J. A. M. A. 112: 2273, June 3, 1939) reported experiments in which they induced attacks of angina pectoris by inflating balloons in the esophagus and thereby producing distention. Wolferth and Edeikin produced three radiographs of spasm of the esophagus in three patients whose attacks resembled angina and one radiograph of the esophagus of a patient during an attack of angina, showing no esophagus spasm.

Jones (Hiatus Esophageal Hernia With Special Reference to a Comparison of Its Symptoms with Those of Angina Pectoris, New England M. J. 225: 963, Dec. 18, 1941) reported 91 cases of small hiatus diaphragmatic esophageal hernia and 37 cases of large hernia, in which substernal pain resembling angina was present in one-third of the small hernias and about one-seventh of the large hernias. Epigastric pain, shoulder pain, arm pain, and accompanying dyspnea and cyanosis were characteristic of the onset in other cases.

Xanthomatosis is described as a cause of coronary artery disease with angina in young persons. Engelberg and Newman (J. A. M. A. 122: 1167, Aug. 21, 1943) report six cases. There is a strong familial tendency. Skin xanthomata in the tendon sheaths, particularly the tendo Achilles, and hypercholesteremia are associated signs.

I have not found in the literature any study which would indicate the relative frequency of the different causes in a consecutive series of patients. Harrison (Clinical Aspects of Pain in the Chest. 1. Angina Pectoris, Am. J. M. Sc. 207: 561, May, 1944) in a very confusing article defines angina pectoris

so that it excludes coronary thrombosis. Then he presents the following causes of "nonanginal pain in the chest or arm in 77 patients with angina pectoris"—whatever that means:

	NUMBER	PER CENT
Coronary thrombosis	35	45.4
Skeletal pain (in muscles, joints or bones in these patients the pain was probably an indirect reflex re- sult of the disease process in the heart)	8	10.4
Spasticity of the alimentary tract	6	7.8
Diseased gall bladder	3	3.9
Hiatal hernia	2	2.9
Pulmonary infarction	2	2.9
Spasm of the diaphragm	1	1.3
Cascade deformity of the stomach	1	1.3
	38	75.9

In my own experience the number of cases of pain in the chest, not due to coronary artery disease as given by Harrison, is very high. In order to try to ascertain the relative frequency of various possible causes of the syndrome I studied 50 consecutive cases of pain in the chest which had the characteristic symptomatology. Every one of them was proved either by the course of the disease, the electrocardiographic studies, or by autopsy to be due to coronary artery disease. I can only conclude that such conditions as hiatus hernia, dissecting aneurysm, and esophageal spasm of such kind that they imitate angina are rare.

X. SYMPTOMS REFERABLE TO DISEASES OF THE RESPIRATORY SYSTEM

A. Cough.—Ryle (The Training and Use of the Senses in Clinical Work, Guy's Hosp. Gaz. 47: 421, Oct. 28, 1933) has the following brilliant description of the differential diagnosis of coughs:

"I would particularly ask your attention to coughs. . . . There is the revolting, hawking, morning, pharyngeal cough of chronic pharyngitis best manifest in the alcoholic. There are the annoying habit coughs of children which cause no harm excepting to the inexperienced mother; the painful, voiceless coughs of grave laryngeal disease; the brassy cough of thoracic aneurysm; and the phthisical cough, which I find difficult to describe, although it has quite definite features of its own. It is not so effortful but, in late cases, as productive as the bronchitic cough; being less tenacious, the sputum is more easily ejected; the cough is more moist and unattended by rhonchus; in the very advanced case it may have a hollow, weary quality. We have also the unmistakable paroxysm of whooping cough, with its repeated expiratory efforts, usually (but not always) culminating in the final inspiratory stridor. How often I have pricked up my ears during a ward round and caught the eye of my house physician in relation to his latest unsuspected admission as 'bronchitis' to one of the cots. I used the adjective 'unmistakable' in connection with the cough of pertussis, but it is worth remembering that a foreign body in the bronchus or a small undischarged pulmonary abscess may give rise to severe and prolonged paroxysms of coughing which are not very dissimilar."

Acute coughs of relatively short duration are usually due to acute rhinolaryngo-tracheo-bronchial infection. Many cases of whooping cough run along without diagnosis and are called a common cold. Elderly people are almost as susceptible to whooping cough as children. This is emphasized in the old trick question of the medical examiner: "If a child comes homes with whooping cough, what member of the household is most likely to catch it?" the answer being "Grandpa."

Foreign body in the trachea should be suspected if a child begins to cough in a strident, brassy manner. Small foreign bodies may pass through the larynx without producing the slightest sensation so that the individual may perfectly honestly have no recollection of the inhalation of the body. To illustrate, a medical colleague of mine was walking up and down his office, idly tapping his front teeth with a pin. (He admits it was foolish.) Suddenly he found the pin gone from his fingers. He searched the floor, failed to find it, had the brilliant thought he might have inhaled it, went immediately to an x-ray colleague, and there it was in a primary bronchus. It floated past his larynx without causing even a change in respiration.

Chronic coughs are found to be due to pulmonary tuberculosis, heart disease (including aneurysm), chronic bronchitis (bronchiectasis), tonsillitis, pleurisy, pharyngitis, asthma, emphysema, and bronchiogenic carcinoma in the order named. Empyema with a fistulous tract into a bronchus is a rare cause.

Mediastinal growths produce a brassy cough reminiscent of aneurysm. Irritation of the diaphragm from gall bladder disease can possibly cause a puzzling cough. Irritation of the external auditory meatus is always mentioned as a possible cause, but it must be extremely rare.

Lung stones, which are calcified lymph nodes which ulcerate through the trachea or one of the primary bronchi, create prostrating paroxysms of coughing before they are freed and expelled.

Bronchogenic carcinoma of the lung is now much more frequently found than formerly, and due to the improved therapeutic technique employed against it and the increasing numbers of cured cases, it behooves the diagnostician to suspect it more often. Cough beginning between the ages of 40 and 65 and persisting without being otherwise explained should suggest bronchogenic carcinoma. Dyspnea, hemoptysis, and weight loss usually accompany the cough, but it was most frequently the first symptom and the persistent one in every series of cases reported.

Voorsanger and Firestone (J. A. M. A. 89: 1137, Oct. 1, 1927) report on a series of patients with "undiagnosed cough" which is defined as a cough of six weeks or more duration, and which in spite of competent examination is still without explanation of a cause. The most striking conclusion which they derived from an intensive study of this group is probably contrary to what most physicians would instinctively presuppose, that very few of them were due to tuberculosis. Fifty-two out of 252 patients with undiagnosed cough were by intensive methods proved to be tuberculous. It is worth noting that these investigators are very emphatic in stating that sputum which repeated examinations proved negative for tubercle bacilli would never produce

tuberculous lesions in guinea pigs. The largest group (34 per cent of "undiagnosed cough") was finally classified as acute bronchitis and asthma, the main etiologic factor of which was a preceding influenza. The next largest group was found on x-ray examination to have enlarged bronchial root glands and various fibrotic areas in the lungs.

B. Hemoptysis must be strictly defined. It means the raising of pure blood, of at least a teaspoonful in amount. It excludes blood-streaked sputum, which may be due to capillary hemorrhage from the pharynx due to the strain of coughing. It excludes the hemorrhagic or rusty sputum of pneumonia and pinkish, frothy, hemorrhagic sputum of pulmonary edema. It connotes the erosion of a vessel of some size, or bleeding from a fairly extensive raw surface (as from a bronchogenic carcinoma).

Thus defined, 99 per cent of all cases of hemoptysis in any general series of cases are caused by pulmonary tuberculosis. Second in frequency is pulmonary infarct in mitral stenosis. (See McMurray: Wisconsin M. J. 25: 297, 1926.) In a bronchoscopic clinic the incidence would change, and there would be a high percentage of cases of bronchogenic carcinoma, foreign body, bronchiectasis, and lung abscess.

Jackson and Diamond (Am. Rev. Tuberc. August, 1942) reported on 436 nontuberculous, nonmitral cases with hemoptysis. The relative frequency of causes was:

	PATIENTS
Bronchiectasis	138
Primary carcinoma of bronchus	82
Tracheobronchitis	74
Pulmonary abscess	51
Adenoma of bronchus	11
Secondary cancer of lung	6
No disease determined	34
Pneumonitis:	
Suppurative and nonsuppurative	26
Miscellaneous:	
Carcinoma of trachea	
Chondroma of bronchus	
Osteoma of trachea	
Dermoid cyst communicating with bronchus	
Broncholithiasis	
Lobar atelectasis	

The syndrome of hemoptysis, afternoon fever, and apical lung signs is just as characteristic of bronchogenic carcinoma as of tuberculosis. The age of the patient is the differential point so far as symptoms alone are involved.

Aneurysm with rupture into the trachea, provided it is not immediately fatal, may seep a few days and present a diagnostic problem. (See Stewart: U. S. Vet. Bur. M. Bull. 5: 214, 1929.)

Parasitic lung infections, as by the Japanese lung fluke, cause hemoptysis, but need not concern the physician in North America or Great Britain. (See Castellani: New Orleans M. & S. J. 79: 20, 1926.)

Mycotic infections—actinomycosis (see Bridge N.: J. A. M. A. 57: 1501-06, 1911) and hydatid disease (see Jauregg: An. Fac. de med., Lima 12: 730) are very rare causes.

The hemorrhagic blood diseases are reported as causes.

Hodgkin's disease as a cause of hemoptysis is occasionally reported (Charr and Wascalonis: J. A. M. A. 116: 2013, 1941).

An unsuspected rib fracture is a not very rare cause for hemoptysis.

Vinson (Ann. Otol., Rhin., and Laryng. 37: 675, 1928) compared 100 patients with pulmonary tuberculosis, 100 with chronic bronchiectasis, and 100 with mitral stenosis with a view to finding the relative frequency of hemoptysis in these conditions. It occurred 29 times in the tuberculous patients, 49 times in the bronchiectasis cases, and 18 times in the mitral cases.

Minor (Am. Rev. Tuberc. Aug., 1943) reported that of 1,000 sanatorium tuberculosis patients, hemoptysis had occurred in 24.3 per cent of them. In 60 patients the hemorrhage was the first remarkable symptom. Thirteen per cent were undiagnosed by the doctor who first saw them.

C. Dysphonia, Hoarseness, Aphonia.—Normal voice production is dependent on three functions of the vocal apparatus: (a) the larynx as the primary source of tone, (b) the chest as the source of motive power, and (c) the chest as a resonant chamber. Change in the character of the voice, weakness of the voice, etc., are usually due to derangements of the second and third factors—the patient too weak to force air through the larynx, the chest filled up with a pneumonic deposit or lung abscess or bronchiectasis. Hoarseness, dysphonia, or aphonia usually point to the larynx alone.

Acute laryngitis is by all odds the commonest cause of hoarseness or dysphonia. An attempt should be made to identify the causative organism, at least to the extent of ruling out diphtheria. Perichondritis as a sequel of an infection—quinsy, typhoid fever, scarlet fever—is a possibility.

"Dysphonia of more than three weeks' standing should be looked on with apprehension until proved otherwise than serious." (Wolf: J. A. M. A. 89: 263, 1927.)

"*Chronic laryngitis*" is a term that should never be used until every alternate possibility has been exhausted. It is a smoke screen that, in most instances, not only does not mean anything, but allows a serious or fatal disease to be carried along by temporizing and comfortable explanations. "The infallible prescription is a gargle. Thus the consultation terminates and the patient goes on—sometimes to certain slow decline and death, just because the doctor was not aware of the many pathologic conditions which might be the cause of the hoarseness, and not sufficiently interested to direct his patient to someone who could give him assistance in making an accurate diagnosis." (Waugh: Cleveland Clin. Quart. 3: 300, 1936.)

The commonest causes of chronic hoarseness (more than three weeks duration) are tuberculosis, neoplasm of the larynx, syphilis of the larynx, aneurism, hysteria, substernal thyroid, bulbar paralysis, and misuse of alcohol and tobacco. Only after these possibilities have been exhausted should the diagnosis of *laryngitis sicca* be made.

Tuberculosis of the larynx is considered by most experienced clinicians to be always secondary to pulmonary involvement. This does not mean, however, that it is always a terminal event. The puzzling and troublesome group of cases are those patients who have never been suspected of having pulmonary tuberculosis, who develop a gradually increasing hoarseness. On examination of the larynx a more or less advanced tuberculous change is found. It may be early and these are the patients who can be cured: therein lies the importance of the recognition. On investigation of the chest normal sputum and doubtful or minimal physical and x-ray signs are found.

All stages and kinds of *syphilis* affect the larynx. A diffuse inflammation described by Bosworth as causing a "peculiar dusky, somber hue of the mucous membrane, which has a dark red or somewhat purplish tint, in contrast to the bright red, scarlet color of an idiopathic inflammation;" *gummata* which ulcerate if untreated, *chondritis*, *nerve paralysis*—all are possible.

The commonest tumors of the larynx are *papilloma* and *carcinoma*.

The relation of *aneurysm* and *mitral stenosis* (with *auricular dilatation*) to hoarseness is the involvement of the recurrent laryngeal nerve.

Laryngitis sicca is the chronic laryngitis due to upper respiratory infection where drippings from the back of the pharynx keep the larynx irritated and inflamed.

XI. SYMPTOMS WHICH POINT TO DISTURBANCE OF THE NERVOUS SYSTEM

A. Coma.—The clinician in taking the history, either from the patient or the patient's relatives, finds he must record some such statement as the following:

"Yesterday (or a few hours ago) the patient suddenly (or gradually) lapsed into a coma, from which he (or she) could not be aroused, and which has lasted ever since."

How is he to evaluate this statement? What diseases are suggested to his mind and in what order of frequency must he place them?

It is simple enough to give an exhaustive list of the causes of coma. But relative frequency of these causes is another thing. It varies with age and many circumstances.

It varies with the type of clinic reporting. Dr. Ernest Sachs reports his experience as follows:

- | | |
|-----------------------------------|--|
| 1. Apoplexy. | 6. Epilepsy. |
| 2. Brain tumor and brain abscess. | 7. Poisoning. |
| 3. Head injury. | 8. Uremia. |
| 4. Diabetes. | 9. Pneumonia and overwhelming infection. |
| 5. Alcoholism. | 10. Meningitis. |
| | 11. Encephalitis. |

But Dr. Sachs is known for his skill as a neurologic surgeon, and cases of brain tumor and brain abscess would naturally be sent to him. In a general practice my experience would indicate that brain tumor is a rare finding as a cause for coma.

Solomon and Aring (*Am. J. M. Sc.* 188: 805, 1934), reporting on a large group of patients who were admitted to a general hospital (The Boston City Hospital), found the ultimate causes to be in this frequency:

	PER CENT
Alcoholism	59.1
Trauma	13.0
Cerebral vascular lesions	10.1
Poisoning	2.8
Epilepsy	2.4
Diabetes	1.7
Pneumonia	1.7
Cardiac decompensation	1.4
Exsanguination	0.9
C. N. S. syphilis	0.6
Uremia	0.6
Eclampsia	0.6
Miscellaneous	3.2

In the poisoning group barbital derivatives, carbon monoxide, bromides, permanganate, lysol, nitrobenzene and sodium nitrate were the agents in order of frequency.

In the miscellaneous group only 3 out of the 38 cases were due to brain tumor (compare this with Dr. Sach's experience). Three were due to encephalitis, but in the time and place where an epidemic is existent, this proportion, of course, would be greatly increased. Hysteria is represented by only 1 case, but this is a record of hospital admissions: the hysteric in coma usually recovers when removal to a hospital is mentioned: the percentage would be higher in general practice. There was one case of hypoglycemic shock from insulin administration. Spontaneous hyperinsulinism should be considered.

The record of exsanguination is valuable. Most of the cases were internal hemorrhage from disease, not injury. The syndrome of internal hemorrhage is almost unknown to the general profession. Some time ago Mr. Irvin Cobb wrote a personal experience which should be a dreadful lesson to all of us. He called it "How It Feels to Die." He related that while on a lecture tour he visited for one successive day and night a number of the large cities of the United States. Every evening as he was dressing for his lecture he felt a sensation of faintness, so much so that he was forced to lie on the bed and nearly always momentarily lost consciousness. Then he recovered, finished his dressing and proceeded with his lecture. In every city he visited he consulted a physician, the most eminent he could find, but with no satisfaction. The final episode occurred when he did not immediately regain consciousness, but woke up to find himself in bed, with his manager, a doctor, and a nurse in the room. The doctor had just completed making a hemoglobin estimate which was 40 per cent (Mr. Cobb had been suffering from acid dyspepsia for some time). He then describes how it feels to die. He went through a series of episodes like this: he felt as if he were gradually sinking through the increasing darkness of the waters of a warm ocean. He sank and sank until

finally he hit bottom. And then equally gently he began to rise until finally he reached the surface of the ocean and *took a long breath*. Finally, on one descent he hit bottom but did not rise. And that is how it feels to die.

But *that* is the syndrome of internal hemorrhage. And none of the eminent clinicians whom he had consulted had even estimated his hemoglobin or asked about the color of his stools.

The routine diagnostic procedure for a patient in coma should be fairly evident:

1. Obtain a specimen of urine and examine for sugar (albumin can wait). Estimate the hemoglobin. I believe these things should be done first because they can be done rapidly and if positive they indicate in either case an immediate and life-saving therapeutic procedure.

2. PHYSICAL EXAMINATION.—“Be rapid and thorough. Remember this is essentially veterinary medicine. Your patient cannot help you. Use your *eyes*: note the patient's color, posture, movements: look for wounds, especially in the scalp. Examine the *pupils*, the *eye grounds* (Sachs states that the ophthalmoscope is the most important instrument in the diagnosis of coma. If dilatation of the pupil is desired, use a transient mydriatic like 1 or 2 per cent homatropine) the *eardrums*, the *throat*. Use your *nose*: Is there an odor to the breath—alcohol, acetone, illuminating gas? Use your *hands*: Feel for a *stiff neck*, for *fractures*, for muscle and vasomotor tone in the extremities, for enlarged *glands*, palpate the *abdomen*, test for *reflexes*. Use your *ears*: Examine the heart and lungs. Take the *temperature*, *pulse*, *respiration* and *blood pressure*.” (Solomon and Aring: *Am. J. M. Sc.* 191:357, 1936.)

3. X-RAY EXAMINATION OF THE SKULL.—This examination should be made while the patient is on the way to the ward unless he is in shock; shock treatment takes precedence over everything else.

4. GASTRIC LAVAGE.—Save the contents of the stomach for chemical examination for poisoning.

5. HISTORY.—Make every effort to obtain the history of onset. This is of paramount importance, but since it takes time and is usually futile, it can wait until the above-mentioned procedures have been done. Talk to friends or relatives who accompany the patient. Talk to the ambulance man. Then send out for the police. Inquire about type of onset, injury, alcohol, other poisons, infection, convulsions, headache, previous illness (diabetes, kidney trouble, heart trouble, pregnancy, high blood pressure).

6. LUMBAR PUNCTURE.—“Routine in all injuries (except during shock), cerebral vascular accidents, convulsions, in the presence of signs of increased intracranial pressure, or meningeal irritation, and in all cases where the diagnosis is obscure.” (Solomon and Aring, *loc. cit.*)

Routine also in any place and time when there is an epidemic of meningococcic meningitis or encephalitis. In meningitis the fluid will show gross pus.

In cerebral vascular accidents the fluid will show gross blood.

The initial pressure of the fluid should be taken.

The Wassermann test should be made and the fluid should be examined for total protein and gold solution, and for the cell count.

Contraindications for lumbar puncture are signs of ever-increasing intracranial pressure from hemorrhage after injury, or tumor where release of pressure might do grave cerebral injury.

B. Drowsiness.—"Death and his brother, Sleep," sang Shelley. "Coma and his twin sister, Drowsiness," say I.

"Joe—damn that boy, he's gone to sleep again," cried old Wardle, anticipating Froehlich by something like sixty-five years.*

The principal symptoms of myxedema are drowsiness, mental and physical lethargy and change of personality. Usually before reaching the diagnosis such a patient is often condemned as a lazy good-for-nothing. Uncontrollable drowsiness should always suggest myxedema.

Bromide intoxication should always be remembered when drowsiness is the complaint. So many people take bromides indiscriminately, with no knowledge of their toxic qualities, that when skin eruptions or mental sluggishness turns up the clinician must be on guard to ask some pointed questions. (See Hashinger and Underwood: J. Kansas M. Soc. 38: 183, 1935.)

Chloral or morphine, when taken for the first few doses by the novice, causes drowsiness. The habitué is more likely to be excited.

C. Convulsions.—

In a valuable study Peterman (Convulsions in Childhood, J. A. M. A. 102: 1729, 1934) records the final diagnosis in 500 children, whose ages ranged from birth to fifteen years. For the entire series the diagnosis was:

	PER CENT
Epilepsy	33.0
Acute infection	22.8
Cerebral birth injury a residue	15.4
Spasmophilia or tetany	13.6
Miscellaneous	8.8
Cause unknown	6.4

NEWBORN TO 1 MONTH (AGE OF ONSET)

DIAGNOSIS	PER CENT
Cerebral birth injury	34.7
Acute infection	12.3
Epilepsy	9.0
Hydrocephalus	6.0
Spasmophilia	6.0
Meningovascular syphilis, congenital	3.0
Gastroenteritis	3.0
Meningitis, streptococci	3.0
Unknown	3.0

*The reference for the information of the heathen among my readers is to the fat boy in Pickwick papers (1836) and to Froehlich's description in 1901.

FROM 1 TO 6 MONTHS (AGE OF ONSET)

DIAGNOSIS	PER CENT
Acute infection	29.4
Cerebral birth injury	23.5
Spasmophilia	16.1
Epilepsy	7.4
Gastroenteritis	4.3
Meningitis, meningococcic	1.5
Unknown	17.6

FROM 6 TO 36 MONTHS (AGE OF ONSET)

DIAGNOSIS	PER CENT
Acute infection	29.3
Spasmophilia	22.4
Epilepsy (idiopathic)	19.4
Cerebral birth injury	12.4
Meningitis (meningococcic, 3; influenzal, 3; streptococcic, 2; tuberculous, 1; staphylococcic, 1)	5.0
Encephalitis residue	1.5
Hydrocephalus	1.0
Brain injury (traumatic)	1.0
Intracranial vascular lesion	1.0
Polioencephalitis, Strumpell-Marie	1.0
Gastroenteritis	0.5
Congenital syphilis	0.5
Pertussis, sequel (intracranial hemorrhage)	0.5
Encephalitis, chronic	0.5
Unknown	4.0

FROM 3 TO 10 YEARS (AGE OF ONSET)

DIAGNOSIS	PER CENT
Epilepsy (idiopathic)	59.0
Acute infection	13.0
Cerebral birth injury	10.0
Tetanus	3.0
Jacksonian epilepsy	2.0
Congenital brain defect	1.5
Brain tumor	1.5
Encephalitis residue	1.5
Residue brain injury (traumatic)	1.5
Hydrocephalus, congenital	0.8
Meningitis, streptococcic	0.8
Congenital syphilis	0.8
Gastroenteritis	0.8
Tertian malaria	0.8
Unknown	3.0

Bennett (Am. J. M. Sc. 178: 677, 1929) reporting on the investigation of 200 patients in convulsive states (presumably adults, although that is not definitely stated) reported the final diagnosis as:

	NUMBER OF CASES
Epilepsy	124
Hysteria	11
Traumatic	9
Brain tumor	10
Brain abscess	2
Cerebrospinal syphilis	7
Encephalitic or meningitic sequelae	5
Cerebral palsy, congenital	8
Cardiovascular disease*	9
Organic and toxic states of obscure etiology	11
Narcolepsy	4

An *initial* convulsion, at different age levels, is (excluding trauma) preponderantly due to:

Birth	Cerebral birth palsy
1-6 months	Acute infection
6-36 months	Acute infection or spasmophilia
3-15 years	Epilepsy
15-30 years	Brain tumor or abscess, meningitis, hysteria
Over 30 years	Paresis, uremia, cerebral hemorrhage

The infantile motor cortex is infinitely more sensitive than the child's or adult's, and minor causes bring on convulsions, so that a convulsion in an infant is not as serious prognostically as an adult's. But nearly 50 per cent of cases in which a convulsion occurs from 6 months to 1 year, turn out to be epilepsy.

Epilepsy appears in many forms and in many degrees of severity. Foster Kennedy speaks of "the spectrum of epilepsy." Temple Fay (Am. J. Surg. New Series, 56: 315, 1942) interprets this idea in these words: "The convulsive state may be so arranged that there exists a gradual shading of attacks from the *larval types* at the one extreme to the full-blown *major seizure* at the other. Some of these attack patterns are characteristic and easily recognized; others assume transition forms and combinations that often make them difficult of diagnosis and classification."

Represented graphically:

Larval attacks—	Dreamy states, temper tantrums, behavior disorder, lapses, sudden altered behavior.
Minor seizures— (Petit mal)	Sudden transient unconsciousness, micturition, objects dropped. Dilatation of pupils, pallor, staring. Twitching of face, arms, fingers, etc. Aura may or may not be present.
Jacksonian attacks— (Focal fits)	Aura, 95 per cent. The cry at beginning of attack. Falling. Full loss of consciousness. Tonus. Clonus. Breath held. Selective motor pattern unaltered by age or training. Loss of sphincter control. Breathing reestablished.
Major seizures— (Grand mal)	Stupor (micturition, defecation, sweating, vomiting). Sleep followed by dull mental state. Mental deterioration.

*Probably the same meaning as the uremia of other writers, as Cabot (*Differential Diagnosis*, Philadelphia, 1910, W. B. Saunders, V. 1, p. 488.

One individual in the course of years may advance progressively through all these gradations.

Trauma may be deceptive in that it may merely initiate either an epileptic phase, or bring out a paretic background, as the image on a photographic plate is made clear by the developer.

The paretic may hibernate successfully, concealing from himself and the world the organic changes occurring in his cortex, and then some extra responsibility or effort will bring out the true condition, in the form of a convulsion. When I was assigned to army duty at a regular army post in 1917, three high-ranking officers had an initial convulsion during my first six months of service. They had been holding down almost dutyless sinecures for several years (an ordnance officer superintending a warehouse of government stores), without displaying any nervous symptoms, until the emergency of war and extra duties overwhelmed their rotting cortical cells, signaling the event in the dramatic form of a convulsion.

The diagnostic procedures which must be instituted in the face of the history of a recent initial convulsion are then quite plain: in the case of an infant or young child, very few, except to establish the nature of a possible infection or toxemia; in an adult, besides a complete physical examination, concentrating on the nervous system and the cardiovascular system, urinalysis, blood chemistry for nitrogen retention, and Wassermann, spinal fluid for all tests indicating central nervous system syphilis, and possibly an encephalogram.

Convulsions may be the lead symptom, and almost the only symptom, in brain tumor. (Gordon: *J. Nerv. and Ment. Dis.* 95: 568, 1942.) The diagnosis in such cases must be established, if at all, on the analysis of that one symptom. For instance: A male, aged forty-five years, had, for two years, attacks of convulsive movements on the left side of his face and left hand. They occurred every eight to fourteen days. They were short in duration and partial loss of consciousness followed the convulsions; the patient was merely dazed. Each seizure was followed by a weakness of the hand, which disappeared in a few hours. The paretic hand was flaccid. During the entire period of two years there were no other symptoms. Suddenly he developed signs of hypertension: optic neuritis and severe headache. At necropsy a glioma was found in the right parietal region.

An initial convulsion in middle age is unlikely to be epilepsy. The differential diagnosis lies between paresis and brain tumor. Characteristics of such convulsions are:

1. They are Jacksonian.
2. Loss of consciousness is rarely the first symptom. Convulsions are followed by loss of consciousness and often when consciousness returns, the convulsions return.
3. A paretic state of affected limit is common after the convulsion.
4. Sensory aura—olfactory, gustatory, astereognosis—sometimes take the place of the convulsion. So do sudden attacks of anarthria.
5. Convulsive seizures of the tonic type, involving suddenly all four extremities with the neck drawn down posteriorly, eyes turned to one side, consciousness preserved, are suggestive of cerebellar tumor.

6. Slight seizures at very short intervals and gross seizures at long intervals are significant for the diagnosis of brain tumor.

D. **Insomnia.**—Occasional insomnia, *la nuit blanche*, happens to all of us. And the insomnia of painful organic disease is understandable.

Chronic insomnia is in my experience always a neurosis. Perhaps this should be qualified to the extent that with some it is a habit. There are light sleepers and those who need only three or four hours sleep a night. But these do not mind it, or have learned to adjust for it—i.e., the fellow who habitually wakes up at 4 A.M., and has learned that the thing to do is philosophically to go to his study and start to work on his monumental "History of Pike County From the Time of Daniel Boone to the End of the Civil War."

Shakespeare was an insomniac and perhaps not very philosophical about it. The plays reek with adjurations to sleep, complaints of sleeplessness, praises of sleep. But, though not entirely philosophical, he was not a neurotic about it.

The neurotic I mean is the lady who blandly informs you she has not slept a wink for three months. She sits before you, buxom, in good weight, with clear skin and eyes, and makes this impossible statement. Sleep is such a necessity that no one can go without it for any length of time—seventy-two hours at most—without suffering such tortures of yearning for it that it becomes a necessity.

In an old-fashioned book, *Hammond on Wakefulness* (J. B. Lippincott, 1866), I find some illustrations of this:

"The power with which this cause can act is oftentimes very great, and not even the strongest exertion of the will is able to neutralize it. I have frequently seen soldiers sleep on horseback during night marches, and have often slept thus myself. Even when the most stirring events are transpiring, some of the participants may fall asleep. Sentinels on posts of great danger cannot always resist the influence. To punish a man with death, therefore, for yielding to an inexorable law of his being, is not the least of the barbarous customs which are still in force in civilized armies. During the battle of the Nile many of the boys engaged in handling ammunition fell asleep, notwithstanding the noise and confusion of the action and the fear of punishment. And it is said that on the retreat to Corunna whole battalions of infantry slept while in rapid march. Even the most acute bodily sufferings are not always sufficient to prevent sleep. I have seen individuals who had been exposed to great fatigue, and who had, while enduring it, met with accidents requiring surgical interference, sleep through the pain caused by the knife. Damiens, who attempted the assassination of Louis XV of France, and who was sentenced to be torn to pieces by four horses, was, for an hour and a half before his execution, subjected to the most infamous tortures, with red-hot pincers, melted lead, burning sulfur, boiling oil, and other diabolical contrivances, yet he slept on the rack, and it was only by continually changing the mode of torture, so as to give a new sensation, that he was kept awake. He complained, just before his death, that the deprivation of sleep was the greatest of all his torments."

Dr. Forbes Winslow* quotes from the *Louisville Semi-Monthly Medical News* the following case:

*On *Obscure Diseases of the Brain*, etc. London, 1860, p. 604, note.

“‘A Chinese merchant had been convicted of murdering his wife, and was sentenced to die by being deprived of sleep. This painful mode of death was carried into effect under the following circumstances: The condemned was placed in prison under the care of three of the police guard, who relieved each other every alternate hour, and who prevented the prisoner falling asleep night or day. He thus lived nineteen days without enjoying any sleep. At the commencement of the eighth day his sufferings were so intense that he implored the authorities to grant him the blessed opportunity of being strangled, guillotined, burned to death, drowned, garroted, shot, quartered, blown up with gunpowder, or put to death in any conceivable way their humanity or ferocity could invent. This will give a slight idea of the horrors of death from want of sleep.’”

E. Delirium.—Delirium is the rambling, incoherent muttering or screaming talk which occurs in the course of acute infections, toxemias, and exhaustive states. It is associated with restlessness and hallucinations. It can be separated from the incoherent talk of the neurotic or hysteric person who usually knows pretty shrewdly what he is saying; also from the muttering monologue of the actual psychotic—melancholiac or idiot—and the excited monologue of the maniac.

As such, delirium is of little *diagnostic* import in the sense that it is often the presenting symptom of a diagnostic problem. Usually the diagnosis has been made—pneumonia or alcoholism—before the delirium appears.

Children become delirious very easily from mild infections, just as they are more susceptible to convulsions than are adults.

Of toxic states, alcoholism is by far the common cause of delirium (delirium tremens, mania à potu).

The *barbiturates* in elderly and arteriosclerotic persons are very likely to cause mental restlessness amounting to delirium rather than the expected sedation.

Among the less frequently met instances of delirium, the *salicylates* and *belladonna* must be remembered as occasional causative agents. I have even seen the amount of atropine needed for an oculist's examinations cause transitory delirium in a sensitized person. *Digitalis* delirium was described by Withering.

Of infections, lobar pneumonia leads the list as a cause of delirium.

Postinfective delirium and psychosis may occur after any infection. The prognosis is good, except that they tend to afflict the mentally unstable. Some of these may be actually encephalitis, such as the encephalitic complications of mumps, measles, and whooping cough.

Exhaustion delirium, as after surgical operations, in troops after long marches or combat, must be remembered.

Uremia, cerebral arteriosclerosis, etc., may provoke delirium.

F. Fainting (syncope) is in every case, I believe, due to withdrawal of circulation from the brain. I once published a short *Note on the Physiology of Fainting*.

“The literature upon syncope or fainting is not large. Allbutt in his *System of Medicine* has a short article incorporated in the chapter on ‘Functional Disorders of the Heart.’ In this he sums up the theory which has

always been current as the cause of fainting—namely, a temporary cerebral anemia due either to a systole of the heart or, in the case of ‘the ladies who are carried out into the vestry,’ to an expansion of the cutaneous or splanchnic vessels.

“The writer within the past two years has had two interesting experiences which correlate each other and perhaps throw some light upon the physiology of the condition.

“In both instances, during a life insurance examination, the applicant has fainted; once while the pulse was being counted, and once while the blood pressure was being estimated.

“The first case was in a young man of perfectly healthy appearance. He was twenty years of age. There was nothing of importance in his previous history or family record. He was standing beside the writer’s desk while his pulse was being counted. The writer’s eyes were naturally upon his watch. He had counted perhaps half a minute when the pulse suddenly stopped; it had been a large, rapid, bounding pulse, and there was no intimation of weakness or irregularity up to the time when it abruptly ceased. So sudden was the transition that the writer thought the artery had rolled from beneath his fingers, and, as he tried to recover it, he felt a tug upon his arm and looked up to find the young man with blanched face and quivering eyelids swaying from side to side, in a moment to tumble in a heap at his feet. On a later examination the patient’s heart and urine were found normal, and there was no other reason for refusing his application for insurance.

“The second experience was with a man of thirty-two who was brought to the writer by an agent of a life insurance company for his opinion upon him as a risk. He had been refused by another company one year previously for albuminuria. He was a man of splendid physique, with no discernible gross lesion of the heart, and a urine which the writer then found to contain neither albumin nor casts. His blood pressure was then estimated; he was seated at the side of the writer’s table and a mercury column instrument used. The writer was looking, then at the mercury column and away from the applicant as he released the pressure in the cuff. The column came down to 60 mm., and as he felt no pulse he glanced at the applicant just in time to catch him as he pitched forward on the desk with complete loss of consciousness. It is of interest in connection with this case that Allbutt quotes Dukes as saying that schoolboys who faint in chapel have albuminuria.

“From these two observations one might argue that in syncope, the heart, for a brief period, entirely stops beating; that in consequence there is an enormous lowering of general blood pressure. This, according to the classic researches of Hill, would cause an immediate cerebral anemia and loss of consciousness.” (Interstate Medical Journal 20: 244, 1913.)

Emotion, fear, nervousness, fatigue, pain, any unusual exertion as straining at stool, or diarrhea, excessive or painful menstruation, are common causes of fainting. With cerebral arteriosclerosis these causes may be of slight degree to result in fainting.

Rare causes are Stokes-Adams disease, Addison’s disease, and hypersensitive carotid sinus.

It is not unusual for anyone on coming out of a faint to have a mild generalized convulsion. This may alarm the family but they can be reassured. It is a regular thing during a fainting spell to have a more or less prolonged period of apnea. The physician should expect this and here too, the family may need reassurance.

G. Vertigo belongs specifically to disturbance in function of the semi-circular canals, and the vestibular branch of the eighth nerve. It ranges in severity from a sense of dizziness, which requires momentary closing of the eyes, to complete loss of equilibrium, such as occurs in severe Ménière's disease. It is regularly associated with nausea and vomiting.

Functional causes are by far the most numerous. These include car sickness, seasickness, airplane sickness, looking from a height, toxic states—food poisoning, alcoholism, infections, ocular reflexes, neurotic states, *focal infections*.

Organic causes—in order of frequency as listed by Cabot (op. cit.)—are anemia (45 per cent), heart disease, tabes, exophthalmic goiter, cerebral tumor (tumors of the frontal and posterior lobe especially), epilepsy, cerebellar tumor (tumor of the eighth nerve, cerebellopontine angle tumor), multiple sclerosis, cerebral and cerebellar abscess.

The nature of his material probably precluded him from seeing aural disease and Ménière's disease; in any comprehensive group of vertiginous patients this would certainly rank high numerically among the organic causes. (See pp. 607-609.)

Drury (J. A. M. A. 87: 26, 1926), studying 1,000 cases of vertigo, was impressed with the large number (734) who had sufficient disturbance of metabolic activity to lead to the suggestion that there was an endocrine origin.

Collins (Med. Record 81: 1019, 1912) in a consecutive series of 425 patients on his service at the Neurological Institute found that only 22 had a primary and presenting complaint of vertigo.

H. Tremor.—Commonest causes of tremor (two numerous to allow of or be of value in a statistical table) are cold, nervousness, fear, fatigue (tremor after manual labor to those not accustomed to it), and old age.

More or less permanent tremor was found in a series of cases to be caused in order of frequency as follows:

	PER CENT
Alcoholism	60.0
Postencephalitic syndrome	15.0
Paralysis agitans	12.0
Exophthalmic goiter	10.0
Morphinism	1.0
Multiple sclerosis	1.0
General paresis (tongue, lips, and face)	0.5
Lead poisoning	0.5
Hyperinsulinism	very small percentage—less than 1 in a thousand

Intention tremor occurs only on attempting a voluntary motion. Notably it is applied to multiple sclerosis. The tremor of exophthalmic goiter is usually an intention tremor.

Continuous tremor is that seen in paralysis agitans and overdosage of insulin.

I. Nervousness.—Well divided by Cabot into *motor nervousness*—person who has the fidgets all the time, cannot sit still, does a panther act up and down the room. Choreiform movements and athetosis would certainly be classified here. *Sensory nervousness*—those who start and jump at the slight-

est noise, or are abnormally sensitive to light, noise, odors, drafts. *Psychic* nervousness—inner restlessness and tension, fear of some impending doom—emotionalism, crying spells. Sweet Alice, if Ben Bolt ever remembers, had *psychic* nervousness.

It is easy to dump all these patients onto the trash heap of the psychoneurotics. But occasionally the symptom may mask an organic disease. I will give an illustration from a colleague's practice:

Dr. B was visited in his office by his colleague, Dr. X, an *oculist*—(an oculist, mind you).

Dr. X, the oculist: "Will you see my brother-in-law in consultation this afternoon?"

Dr. B: "Yes, what time?"

Dr. X: "Well, that depends on when we find him."

Dr. B: "What happened to him?"

Dr. X: "*This fellow is very nervous. He is one of the most brilliant businessmen I have ever known. He has an intellect like chain lightning—always thinking, planning, scheming. But he has been under a terrible strain and I think it's been too much for him.*

"He just completed a deal in Oklahoma that will probably net him over a million dollars." (This proved to be no exaggeration by the patient.) "Now he has been working on an idea and he came up here to the Bank of Commerce to finance it; the officials there thought it was a magnificent idea but they said it was too big for them, so they sent for officials from the National City Bank, of New York. They have been in conference with my brother-in-law all week. They entirely approved the plan, are ready to advance the loan, and had the papers all drawn up today. My brother-in-law went over there. The National City Bank officials signed the papers and pushed them over to my brother-in-law when all of a sudden he said, 'What time is it?' 'Twelve o'clock,' was the answer. 'I've got to go meet my wife.' 'But look, all you have to do is sign these papers. It won't take a minute. Then you can go meet your wife.'"

"My brother-in-law got very excited. He said, 'Nobody is going to keep me from meeting my wife on time,' put his hat on and walked out without signing the papers. We haven't seen him since and can't find him."

When they did find him his pupillary curve and spinal fluid Wassermann were good and positive.

Chapter 4

THE PHYSICAL EXAMINATION

"When you no longer know what headache, heartache, or stomachache means without cisternal punctures, electrocardiograms, and x-ray plates, you are slipping."—Martin Fischer.

After the history has been recorded, the next step in diagnosis is the physical examination. Here the physician accumulates the facts in the changed condition of the patient's body revealed to his unaided senses of *sight, feeling, and hearing*. (Smell is sometimes used, as in acetone odor on the breath.) By "unaided sense" is meant unaided by chemical or instrumental means: it is true that some very simple instruments, such as a stethoscope or a thermometer, are used, but these are merely conveniences or are used for purposes of exactness; they could be dispensed with. You can hear the chest sounds without the stethoscope (in fact some diagnosticians think they can hear them better that way), and you can tell whether a person has a fever without a thermometer, but not exactly how much.

In the Examination Room, the Following Simple Accessories Should Be at Hand:

1. Chair for examiner.

2. Stool, of piano stool type, for patient. This is better than a chair for examining the chest. The patient can be turned so that all sides of the chest can be examined.

3. Head mirror and tongue depressors. *Light for reflection.*

Experience has taught me to revolt against the habit of examining the oral cavity by allowing the patient to stand up, with the examiner standing in front and using a wooden tongue depressor in one hand and a small electric flashlight in the other. My objections to this bad technique are, first, that in two-thirds of instances the level of the patient's open mouth is wrong for the examiner's eyes; second, it is done in daylight, or general room lighting, which ruins the examination of the eyes and half ruins the examination of the oral cavity; third, with the wooden tongue depressor the examiner's knuckles and fist are in the way of his vision, and, last, with one hand using the electric flashlight the anterior pillar of the fauces cannot be pulled aside, the tonsil cannot be examined, and the cheek cannot be retracted so that the inside of it can be seen. Proper technique is a nose and throat chair, a head mirror and two metal retractors with the handle below the depressor surface.

4. Thermometer.

5. Scales.

6. High, solid table six feet long for examination of abdomen.

7. Sphygmomanometer.

8. Stethoscope.

The Order of Physical Examination of Any Part Is:

- | | |
|----------------|------------------|
| 1. Inspection. | 3. Percussion. |
| 2. Palpation. | 4. Auscultation. |

The General Methods of Physical Diagnosis

1. **Inspection.**—Although what he learns from sight is the most valuable information the physician gets, there is little that can be done to teach the technique of inspection.

As his knowledge of pathology and of physiology and of physical signs increases, the value of his inspection will increase rapidly. Accomplished diagnosticians are astonishingly adept at inspection.

"In the old Neusser division at Vienna," wrote the late LeRoy Crummer in his valuable book on *Heart Disease*—"cardiac riddles were always brought for solution to the Cvostek clinic, and it was our greatest admiration to see him invariably make the correct diagnosis by inspection alone, the while standing across the room from the patient."

Disease leaves its mark upon the look in a man's eye, the mottling of his skin, the swing of his leg, the bend of his back, the heave of his chest. It is for you to learn to read those signals.

The trained observer always sees more than the untrained no matter how keen the eyesight of the latter. As a matter of fact, behind the keen eye of the woodsman is little else than a knowledge of the habits of animals and plants and knowing what to expect.

As I look at a blue spot on a person's cheek a thousand scraps of organized knowledge come into my head—the different kinds of pigment in the body, what melanin is, the histology of a melanotic wart, the histology of a nevus, the chemistry of cyanosis, the cause of dilated facial vesicles. Such is the named art of seeing. It does not consist in stupidly staring endlessly at an object, but in sending the mind out into the world and finding out as much as possible which applies to the elucidation of what is before you.

There are two aids to inspection—transillumination and slit lamp inspection. Transillumination is limited, however, to the teeth, sinuses, the breast, and the scrotum.

Slit lamp illumination consists in throwing a beam of light across the skin in order to see slight protrusions, pulsations or wormlike movements which might otherwise escape detection in ordinary daylight. The light may be produced by an ophthalmoscope with the head attachment off or a fountain pen type of flashlight, or a flashlight with the lens covered with adhesive except for a narrow segment with a 10 degree angle.

The slit light obliquely pointed accentuates every depression and protrusion and makes every pulsation a magnified moving shadow. It is useful in detecting a tracheal tug, carotid pulsation, the apex impulse of the heart, enlarged edge of the liver, peristalsis of the stomach or bowel, ladder pattern in intestinal obstruction, and aneurysmal bulges and superficial tumors gener-

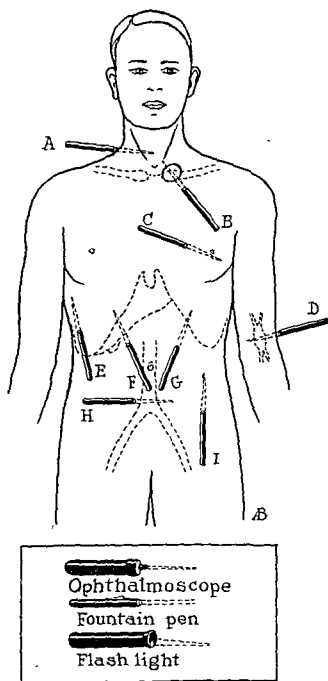


Fig. 4.—Inspection by the use of the slit lamp. (After Reich.)

ally. (Reich: Slit Lamp Principle. Its Use as a Simple Aid to Inspection in Diagnosis, New York State J. Med. 38: 1398, Nov. 1, 1938.)

2. Palpation.—Palpation, or feeling, in order to elucidate a diagnosis is used thus:

(a) Of inflammation—note local temperature of the part, infiltration, ulceration, and fluctuation.

Infiltrated tissues are described as soft, or brawny, or indurated, or sandy. If an ulcer is present, describe the feel of the edges.

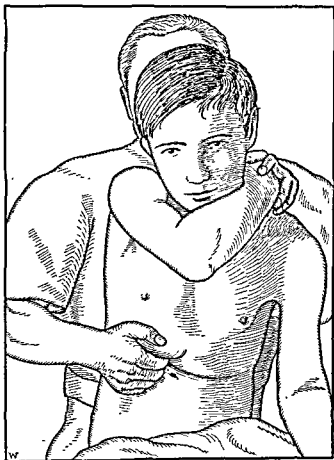


Fig. 3.—Murphy's deep grip palpation.

To test fluctuation. From Bailey's book on *Physical Signs in Clinical Surgery* I quote:

"Fluctuation is the most elementary and probably the oldest sign in surgery. . . . We shall proceed to examine a swelling of moderate size for fluctuation. The pulp of the tip of the forefinger is placed halfway between the center and the periphery of the swelling. This is the 'watching finger' and is kept motionless throughout the procedure. The right forefinger is now placed upon a point at equal distance from the center, diagonally opposite the first. This is the

'displacing finger.' If the watching finger is displaced by the pressure exerted by the displacing finger in both axes of the swelling, then fluctuation is present and we know that the swelling in question is fluid."

(b) A mass or growth—including an abdominal tumor—should be described in these terms:

Size: Use familiar terms—an almond, a watermelon, an orange, etc.

Shape: Round, oblong, lobulated, stringlike.

Consistency: Is its consistency equal throughout? Is it solid or an encapsulated fluid?

Movability: Is it movable or fixed? To what is it attached?

Nature: Is it the enlargement of an organ in its normal site, or a new growth?

(c) Crepitation is a grating feeling elicited over inflamed areas, particularly joints on movement, over the two ends of a fractured bone, and over subcutaneous emphysema.

(d) Pitting of the skin on pressure is a sign of subcutaneous fluid, either inflammatory or due to stasis (lymphatic or venous) or to cardiac or renal failure.

(e) Tissues over an inflammation, as the muscles and skin of the abdominal wall or thorax, the muscles and skin over an injury of an extremity, or inflammation of bone or joint, such as osteomyelitis or tuberculosis, are palpated for tenderness, spasm, rigidity.

(f) *Fremitus.* Vocal fremitus is the vibratory sensation transmitted to the hand placed on the chest when the patient speaks. It is increased over consolidation, decreased or absent with bronchial obstruction or pleural thickening or pleural fluid.

(g) Thrills are felt over the heart or great vessels when an obstruction obstacle is in the blood stream.

What is said about teaching inspection applies to palpation. While it is possible to teach a few of the maneuvers of palpation, such as how to palpate a spleen, the ultimate expertness of the art consists in just such knowledge of anatomy, physiology, and pathology as was indicated above under inspection.

3. Percussion.—*Percussion consists in striking or tapping or stroking the surface of the body to elicit a sound.*

As usually performed, the middle finger of the examiner's left hand is pressed against the skin and the middle finger of the right hand strikes it a direct blow. The blow should be sharp and delivered at right angles. The stroke should come from the wrist, not the elbow. The percussed finger should be pressed firmly against the part which is being examined.

The percussion notes elicited are resonance, dullness, flatness, and tympany.

Resonance—or vesicular resonance, or pulmonary resonance—is the note elicited over healthy lung tissue—the right chest from apex to fourth rib, the left chest except over heart area and over Traube's semilunar space, the axillae and the back of the chest.

Dullness is the note heard over lung tissue that is partially infiltrated or consolidated, or an area with lung tissue overlying a solid organ.

Flatness is the note heard over solid, non-air-containing organs—liver, heart. The typical note of flatness is that elicited when percussing on the thigh—Schenkel tone.

Tympany is the note heard over a hollow air-containing viscus—stomach, intestines. The abdomen normally gives off a tympanic note all over

Amphoric resonance (over a cavity with rigid walls) and cracked pot resonance (forcible *direct* percussion over a cavity with an opening into a bronchus: the strength of the percussion stroke forces air from the cavity into the more or less collapsed bronchus) are pathologic and of little diagnostic value.

Hyperresonance occurs in emphysema and over lung tissue above pleural fluid. (The latter called also skodaic resonance.)



FIG. 6.—Technique of percussion.

Percussion is the politest accomplishment of the clinician. Skill in percussion and in its interpretation comes only with practice; the student should practice it as a singer practices scales. Over and over he should percuss down the midclavicular line on the right chest until he is accustomed to the finest gradations between the resonance of the upper part, the relative dullness between about the fourth and sixth rib (lung overlying liver), the flatness over the area from the sixth rib down to the abdomen (liver), and the tympany over the abdomen.

Practice is the most important thing in becoming adept at percussion, but a few principles will help. A musical ear is helpful but not necessary. For those who are confused, it is well to disregard any attempt to recognize pitch and determine the duration of the sound—the high-pitched sound is shorter than the low-pitched sound.

Pulmonary resonance is not a musical note, but a noise. Helmholtz (*On the Sensation of Tone*, 1862) wrote: "The sensation of a musical note is due to a rapid periodic motion of a sonorous body: the sensation of a noise to non-periodic vibrations." Tympany is a musical note with overtones. Pitch is determined by the number of vibrations per second of an air column—the more rapid the rate, the higher the pitch. The longer the air column set in motion, the lower the pitch. Thus the sound elicited by percussion over the lung apex above the clavicle is higher pitched than the note over the lung below the clavicle. Infiltration of the lung tissue from pneumonia or tuberculosis will raise the

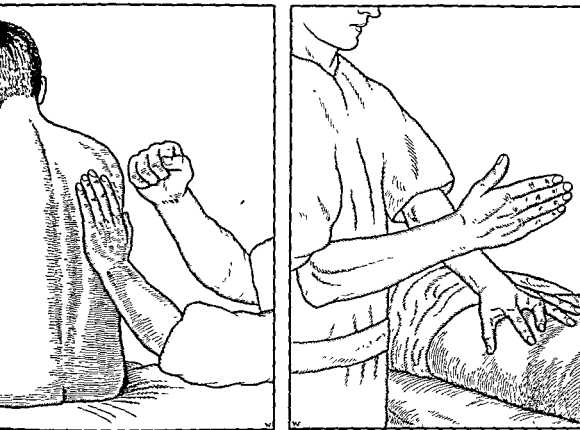


Fig. 7.—A, Murphy's fist percussion; B, Murphy's hammer percussion.

pitch; as the infiltration increases, dullness or flatness is reached. Fluid in the pleural cavity causes a flat note. Loudness is due to the amplitude of the vibration. Pitch and loudness have nothing to do with each other. The beginning physical diagnostician soon learns that the note over a pleural effusion cannot be heard as well as the note over vesicular lung tissue. It takes him a long time to get used to this. Percussing with the same force he is likely to think instinctively that when he runs from resonance to dullness it will be immediately evident. Perhaps the only evidence of it may be a diminution or complete loss of the note.

A layer of lung tissue 4 cm. or more in thickness in contact with the chest will give the typical note of resonance. "If therefore an area of consolidation, a tumor, aneurysm, or solid viscus, lies more than 4 cm. below the surface of such a layer of normal tissue, it will give no evidence of its presence on percussion." (Buck: *The Essentials of Physical Diagnosis*, W. B. Saunders Co.)

Light percussion is always to be preferred. If you percuss so lightly that you have to put your ear down to hear the note, you will be surprised at the fine distinctions you can recognize.

Auenbrugger, in his classic description of percussion (1761), summed up the entire subject tersely as is shown by the following extract:

"The thorax of a healthy person sounds, when struck.

"The sound thus elicited from the healthy chest, resembles the stifled sound of a drum covered with a thick woolen cloth or other envelope.

"To be able justly to appreciate the value of the various sounds elicited from the chest in cases of disease, it is customary to have learned by experience on many subjects, the modifications of sounds, general or partial, produced by the habit of body, natural conformation as to the scapulae, mammae, the heart, the capacity of the thorax, the degree of fleshiness, fatness, etc., etc., in as much as these various circumstances modify the sound very considerably."

"If a sonorous part of the chest, struck with the same intensity, yields a sound duller than natural, disease exists in that part.

"If a sonorous region of the chest appears, on percussion, entirely destitute of the natural sound—that is, if it yields only a sound like that of a fleshy limb when struck—disease exists in that region.

"These varying results depend on the greater or lesser diminution of the volume of air usually contained in the thorax (lungs); and the cause which occasions this diminution, whether solid or liquid, produces analogous results to those obtained by striking a cask, for example, in different degrees of emptiness or fullness: the diminution of sound being proportioned to the diminution of the volume of air contained in it."

4. Auscultation—The Acoustics of Percussion and Auscultation.—

A. THE INSTRUMENT.—

"Three dollars puts the stethoscope in the hands of the medical student. Its initial cost is trivial, its maintenance and depreciation charges are not worth mentioning, it does not require an extra room at fifty dollars a month to house it, and no extra charge is made to the patient if it proves necessary to use it. It is portable, convenient, almost indestructible. Regardless of age, sex, race, or religion, the stethoscope is available for everyone within reach of a doctor. It is applicable in the hospital, in the home, or on the street corner. It pours its secrets unreservedly into the ears of him who will only listen and brings great fame to him who learns to interpret its small voice." (James J. Waring: *Am. Rev. Tuberc.*, 1936.)

Direct auscultation with the examiner's ear against the patient's chest, while used until recently in some European clinics strikes most American diagnosticians as an affectation, and the objections to it are exactly what Laennec found them in 1861, when he invented the stethoscope. "I was consulted by a young woman who presented some general symptoms of disease of the heart, in whose case the application of the hand and percussion gave but slight indi-

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cations on account of her corpulency. On account of the age and sex of the patient, the common modes of exploration being inapplicable, etc." In other words, the configuration of the human chest seldom fits the examiner's ear.

The monaural stethoscope, a modification of Laennec's original instrument, is praised by some clinicians who claim they can hear sounds with it that are inaudible by other instruments. Its advantages are that it transmits sounds by both air and bone conduction and that the conducting tube is rigid as compared with the rubber tubes of the binaural stethoscope. But these advantages are slight compared with the disadvantages of having one ear left open and being compelled to assume a position of great awkwardness while auscultating.

Binaural stethoscopes have chest pieces of two kinds—the open bell and the diaphragm.

In principle all stethoscopes are simply for the purpose of localizing and accumulating sounds. The bell of a stethoscope covers an area of skin and makes it taut so that it serves as a diaphragm: although in so doing, especially if there is a considerable layer of subcutaneous fat, it also smothers and masks sounds. The stethoscope operates on the well-known principle of auditory localization, or the ability to ascertain the direction of a sound source by means of phase differences.

The less pressure that is made by the bell of a stethoscope on the skin of the chest the more chance there is of hearing faint, high pitched murmurs, the third heart sound, and differential sounds. The diaphragm type of stethoscope automatically accomplishes this, and for this reason is favored for examination of the heart in certain circumstances. However, a convenient instrument combining both bell and diaphragm chest pieces is available.

The larger the diameter of the stethoscope bell the greater the amount of sound collected, and the greater the sound intensity. The experiments of Rappaport and Sprague (Op. cit. infra) substantiated this popular belief. A bell with a smaller diameter, however, localizes sounds better, so the examiner must make a choice of which he wants. Since there is no reason, he should not go over all parts of the chest with a small bell, the advantage of the accumulation of sounds from a wide area seems to me secondary.

With a diaphragm bell of given size the greater the pressure with which the bell is applied to the patient's chest, the less the apparent intensity of the first and second sounds of the heart and the higher the pitch. The smaller the diameter of the bell, the higher the pitch of all sounds.

The most careful localization can be made by using the phase difference phenomenon developed by the necessity for detecting submarines. For this is needed a double bell, as used in the symballophone developed by Kerr, Bassett, Goldman, and Althausen. In practice, however, we have not found the symballophone useful; in fact, it is even confusing.

Amplifying stethoscopes are, in my experience, a delusion and a snare. Many instruments which claim amplification are no better than those of ordinary design. The amplifiers with electrical attachments really amplify but require more or less cumbersome apparatus and attachments, which violate the

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first principle of the advantage of the stethoscope as pointed out in the excerpt from Dr. Waring—its essential simplicity. Besides for most auscultators the trouble with listening to the chest is not that they do not hear enough, but that there are more sounds than they are able to interpret.

Graphic sound records are somewhat used but the advantages claimed for them are debatable. It is said "the customary method of auscultation with the stethoscope is fraught with the danger of personal equation," while graphic records "obtained from the same patient at different intervals enable the physician to follow the evolution of the condition and the effect of therapeutic measures." But at present "graphic recording by all human means is subject to wide variation and error, and the incapacities of audion circuits and phonograph recordings are fully as objectionable as the personal equation present when the trained examiner is listening, with the common stethoscope." (See correspondence between Joseph K. Narat and Douglas MacFarlane: J. A. M. A. 111: No. 12, Sept. 17, 1938.)

Most of these discussions revolve about difficulties which do not exist. The amount of information which can possibly be picked up with a stethoscope is valuable and definite, but completely limited. The idea that if you heard everything in the chest you would be able to make any diagnosis is nonsense. The average practitioner, instead of experimenting with trick instruments and machines, would do better to get a simple type of stethoscope and spend his time in a quiet room with one patient over several hours at a session, whence he will come out with as much data as he can well interpret.

B. THE RECEPTIVE APPARATUS.—"Our ears are only machines to translate air waves into a form suited to stimulate the auditory nerve: and as machines we may measure and describe them in the same terms that apply to devices we ourselves construct. We may compare them as to performance and may accommodate our devices to their requirements." (H. D. Arnold in introduction to Harvey Fletcher's *Speech and Hearing*, New York, 1929, D. Van Nostrand Co., Inc.)

The decibel is the unit of sound intensity used by communications engineers to measure variations of which the human ear is capable of perception. Equal variations of sound intensify along a logarithmic or decibel scale and approximate equal variations of loudness as perceived by the normal human ear. One decibel variation in power level of sound is approximately the minimum change that may be detected by the average human ear.

In order to get some idea of the level at which the ear operates when listening to sounds within the chest, I list below a few of the comparative examples given by Rappaport and Sprague. (*Physiologic and Physical Laws That Govern Auscultation*, Am. Heart J. 21: No. 3, March, 1941.)

Hammer blows on steel plate at a distance of 2 feet have a noise level of 114 decibels (almost at the threshold of pain)—amplitude ratio 501,200.

Riveter at 35 feet—97 decibels—amplitude 70,000.

Average automobile—15-50 feet—66 decibels—amplitude 1,995.

Ordinary conversation—3 feet—65 decibels—amplitude 1,778.

Very quiet radio—3 feet—40 decibels—amplitude 100.

Whisper—4 feet—20 decibels—amplitude 10.

Rustle of leaves in gentle breeze—10 decibels—amplitude 3.1. (The classic illustration for inspiration.)

“The intensities of the sounds of the chest are very small, not averaging for the frequencies they possess, more than 10 decibels at their greatest exaggerations. The frequency characteristics of these various sounds are contained in a very narrow band between 60 and 1,000 cycles. In other words, whereas the normal hearing range lies roughly between 60 and 26,000 cycles, for listening to chests and hearts one is required to have good hearing only in the zone 64-1,000. Yet a small hearing loss in this restricted area will make the usual chest sounds inaudible.” (MacFarlan: *The Acoustics of the Stethoscope*, J. A. M. A. 110: No. 25, June 18, 1938.)

The human ear is a far better detector of changes in frequency (pitch) than in changes of intensity (loudness).

MacFarlan states that normal heart sounds have a frequency of 50 to 110. Above these frequencies the intensities are negligible, which is one reason why amplifying stethoscopes contribute so little. Heart murmurs—low pitched—have frequencies below 400 cycles. Heart murmurs—high pitched—120 to 660 cycles. Presystolic murmurs—below 140 cycles usually, but may go up to 400 cycles. Pericardial rub between 140 and 660 cycles. Râles—between 120 and 1,000 cycles. Bronchial breathing between 240 and 1,000 cycles. Amphoric breathing—between 240 and 660 cycles.

The ability of the ear to recognize a tone of brief duration decreases as the duration decreases. (Stewart's principle. See Stewart, G. W.: *Problems Suggested by an Uncertainty Principle in Acoustics*, J. Acous. Soc. America 3: 325, 1931.)

Damping or Masking Effects.—The ability of the ear to detect certain sounds in the presence of other sounds is reduced, a phenomenon technically known as masking. Everyone instinctively knows this and allows for it by raising the voice in conversation in competition with a noisy environment. The higher pitched notes are masked earliest. The only practical lesson to be derived from this principle for physical diagnosis is the sensible one that *auscultation should be carried out in a quiet room.*

As sounds pass through different media, some of the media accelerate (relatively) and some dampen the sounds. The skin and subcutaneous fat are good dampeners. The harder the stethoscope is pressed against the chest the greater the dampening effect.

C. THE HUMAN THORAX AS AN ACOUSTIC INSTRUMENT.—The philosophic and scientific physical diagnostician must learn the capabilities and limitations of his instruments—the percussing fingers and the stethoscope. He should also know the capabilities and limitations—one feels like reversing this and saying limitations and capabilities of his own receptive auditory apparatus. These two topics we have just considered. And if he is truly philosophic and scientific, he should also be acquainted with the acoustic properties of the instrument he plays—the human thorax. In short, he should know the bow, the ear and the fiddle.

This I emphasize is in his philosophic moods. In actual practice he can learn all or nearly all that is necessary about the physical diagnosis of the chest without considering the acoustics of the matter at all, just as a man may be a painter of genius without knowing anything about the theory of colors.

The reasons for this are, first, that a knowledge of acoustics does not really help as much in the interpretation of physical signs as would appear beforehand. Second, it is not always easy to make acoustical theory fit into the signs we recognize. At any rate the students of the subject have not been very successful in agreeing upon the cause and nature of the sounds produced nor very clear in their voluminous exposition of them.

But for what they are worth I will endeavor to recapitulate the ideas which have been advanced.

The qualities of sound are intensity, duration, quality, and pitch. Intensity, or loudness, depends on the amplitude of the vibrations of the air column. Duration depends on the amount of air in the column: the more air the longer the duration: resonant and tympanic tones are of long duration, dull and flat notes are short. Quality denotes a note which either is or is not musical: on the number and quality of the overtones. Pitch depends upon the rate of vibrations, number per second; the more rapid the rate, the higher the pitch: the longer the air column set in motion, the slower the vibration and the lower the pitch.

Austin Flint thought pitch was the most important element in the analysis of sound, and he influenced all subsequent thought on physical diagnosis in that direction. Duration, however, is probably for most diagnosticians, especially those without acute musical perception, a more constant factor in perceptibility and differentiation. Vibrations must last one-fourth of a second to be audible: absolute dullness on a percussion note is close to this.

The human thorax is a resonator. In a favorite experiment in physics a vibrating tuning fork is held over the mouth of a tall beaker while water is poured into it: at a certain exact level of the water, the sound of the tuning fork is augmented until it can be heard throughout the room: if more water is added the sound of the tuning fork reverts to its almost inaudible hum. The level at which it was augmented represents an air column that agrees with the frequency of the vibrations of the tuning fork. This is the simplest type of a resonator.

No musical instrument, however, is a simple resonator. There are forced vibrations which result in sounds. If you place a vibrating tuning fork handle down on a table or desk it will give off louder vibrations. The table or desk contains a number of unequal air spaces so that it cannot be considered as a simple resonator, but the vibrations of the tuning fork are forced on it and shake it so that it produces a sound which the tuning fork cannot produce alone. A violin or a piano is such an instrument: they are able to make a loud sound at any pitch.

The human thorax is obviously such an instrument.

The thorax responds to percussion, to the spoken or whispered voice, or to vesicular breathing, and in doing so a number of different elements are thrown

in vibration—the lung parenchyma, the larger air spaces in the bronchi, and the chest wall.

Let me repeat here that the percussion note over healthy lung tissue is a sound, not a musical tone. The note over the abdomen is a musical tone. This is because a musical tone is a set of vibrations. If you had a drum, a sponge, and a beefsteak and struck the drumhead with a stick you would get a musical tone because the tense drumhead would stay in vibration for a time after it was struck. Thus the gas-distended coils of the intestines produce a musical tone on percussion. The sponge and the beefsteak would give out a sound—they would not vibrate—when struck with the stick, the analogy being to percussion over the lungs and over the liver or thigh.

The thorax resonator has some peculiarities. The sound elicited by percussion (which has a frequency of about 108 vibrations a second) is not due to striking an uninterrupted air column. The air cavity of the thorax is multi-locular like a sponge or pillow. The total volume of air cells make the resonance plus a system of air tubes, the bronchi, which is also a resonator, but one of smaller volume, the fundamental sound of which is necessarily of a higher pitch. "In percussion of the normal thorax the note is composed of quite high tones from the impact of the blow on the pleximeter, moderately high tones from the vibration of the chest wall, and also from the resonance of the bronchial system and the deep tones of thoracic resonance." (Bushnell.)

The role which the vibrations of the chest wall play in the formation of the percussion note is debatable. Martini (*Studien über Perkussion und Auskultation, Deutsches Arch. f. klin. Med.* 139: 65, April, 1922) is authority for the statement that the exenterated and inflated lung gives out the same percussion note as that of the thoracic note before the removal of the lung. This may mean that as a resonator the vibrations of the chest wall are the same as the vibrations of the cavity, however, the vibrations are forced on it. Percussion of the thorax over a closed pneumothorax cavity is, in my experience, almost indistinguishable from ordinary resonance or slight dullness, although authorities usually state that it "varies from tympany to dullness depending on the state of tension of the air." This sounds like mere lip-service to tradition, rather than if written with actual cases under examination in the same room with the writer. Laennec, whose descriptions were always written with specific cases in mind, wrote under *Signs of Pneumothorax*, "Percussion alone and unaided furnishes no constant information. When the gaseous effusion is very large the affected side yields a clearer note than the healthy side. If often happens, moreover, in cases of pneumothorax complicated by pleural effusions, either that both sides are equally resonant or it is the affected side that is less resonant. If for once by chance the tympanitic sound and the dilatation of the chest lead to a correct diagnosis of pneumothorax, as they did M. Bayle in a case we have previously mentioned, it will happen much more often that these signs deceive rather than illuminate." It is a matter of some practical importance whether the chest wall vibrates, certainly in the diagnosis of pneumothorax, and the conclusion seems to be that it vibrates in the same frequency as the contained lung.

The vibration of the chest wall under tactile, or vocal fremitus, is a matter of the transmission of waves through the thorax rather than of percussion note.

The percussion note under diseased conditions varies with the tension of the alveolar walls and infiltration of the air spaces by exudate or replacement by scar tissue. Percussion over a fresh loaf of bread yields resonance, over a stale loaf tympany. The emphysematous note and skodaic tympany, or hyper-resonance, are examples of this principle. The shorter a column of air the higher its pitch when put in vibration: this forms the basis of higher pitched notes—dullness to flatness—over pneumonic or tuberculous consolidations and infiltrations.

The Origin and Transmission of Sounds or Waves Through the Chest.—

There is a general agreement among authorities as to the way the sounds produced by the heart and great vessels are transmitted through the chest. The movements of blood, valves, etc., produce vibrations in the walls of the containing vessels which are transmitted directly to the chest wall. When the heart is in systole, for instance, the apex is against the chest wall and the vibrations are transmitted directly to the stethoscope bell.

About the origin and transmission of the respiratory sounds, however, there is no such final agreement.

There are two kinds of pipes for the production of sounds or musical notes: the reed pipe and the labial pipe. In the reed pipe a vibrating tongue, or membrane, is set in motion by a stream of air. In the labial pipe air under pressure issues from a narrow opening and strikes against a sharp edge. The issuing column of air is thrown into vibration against the sharp edge and if the edge is close to a column of air, as in an organ pipe, the column of air is thrown into vibration, producing a note of the pitch of the fundamental tone of the organ pipe.

"If one blows through a glass T tube a sound is produced. The air issuing from the side tube at high velocity is set into vibration both as it leaves the side tube and emerges into the other tube and as it strikes against the wall of the other tube." (Fabr.) This is essentially a labial pipe and the conditions correspond to the anatomic structure of the lower respiratory tree and of the physiologic conditions during respiration.

The respiratory murmur as heard at the chest wall during inspiration is a resultant of the sounds produced by the passage of air through the buccal and nasal cavities, past the larynx, down a series of bronchial tubes of always smaller caliber and out into the alveoli of the lungs. The ordinarily accepted view, in fact what might be the instinctive idea, about the production of breath sounds is that this system acts like a reed pipe and forces its combined vibrations on the chest as a resonator. When the note gets into the alveoli it is considerably diffused and dampened.

Martini and Mueller have shown that the bronchial breath sounds have a pitch between c-1 and d-2, a frequency between 350 and 540 vibrations a second. They have overtones of approximately 1,000 vibrations a second, or around c-3 on the musical scale. They also determined by graphic methods the frequency of free vibrations in different parts of the respiratory system and found them

as follows: nasal and buccal cavities—400 per second, trachea below the larynx—800 per second, primary bronchus—1,000 per second, secondary bronchi 1,200 per second, and smaller bronchi down to 1,700 per second.

Is the respiratory system a labial pipe or a reed pipe? Col. George E. Bushnell, M. C., U. S. Army, was a conscientious student of respiratory acoustics and came to the conclusion that it is a reed pipe and that the vocal cords constitute the tongue of the pipe. By training he was able to relax his vocal cords and bucconasal cavity so that they produced no sound on inspiration and expiration and in this state, as determined by such good observers as Drs. Joseph H. Pratt and G. P. Granfield, the vesicular murmur over his chest disappeared.

The observation, as Col. Bushnell discovered, after his first contribution was published, had been made as long ago as 1834 by a French physician, J. H. S. Beau, who wrote: "I then asked whether it would not be possible for him (a patient with a loud *"tubal souffle"*) to breathe without making the least sound and he succeeded in doing so after a few attempts, opening his mouth widely. I ausculted again and heard nothing. During all this time, respiration had not lost its frequency, and the chest walls rose as rapidly and as amply as before the experiment."

The most convincing of Col. Bushnell's critics was Martini, of Munich. He found the vesicular murmur to persist not only after the larynx was relaxed, but with a tracheoscope in place. Fahr ausculted a number of persons who had a bronchoscope in place and one who had had the larynx removed surgically and found the breath sounds everywhere normal. Bullar (Proc. Roy. Soc. Lond. 1884) was able to hear the vesicular murmur in an exenterated specimen of lungs, with a plug in the trachea, when the air was forced from one lung into the other, and a stethoscope was placed over the receiving lung.

The conscientious student of physical diagnosis will want to repeat as nearly as possible Col. Bushnell's experiments and find out for himself. In doing so he will learn a great deal about the physical diagnosis of respiration. I have never been able to make the vesicular murmur completely disappear, perhaps because neither I nor my subjects were able completely to relax the glottis, but there is no question that, with the gradual elimination of the glottic element, the vesicular murmur gets fainter and fainter.

Martini sums up the two theories as follows: "According to one theory, the specific vibrations of the porous tissues of the lung, put in motion through respiration causes vesicular breathing: the second theory maintains that the vibrations of the bronchial system alone force their specific frequency on the tissues of the lungs and on the chest and wall respectively, there either weakened or strengthened, according to the physical conditions of the vibrations of the air and of the conducting tissue of the lung. To the latter process, the laws of the so-called forced vibrations, as first proved by O. Frank, should be applicable. These laws may be of interest:

"1. A correct conduction of sound is possible only if the specific sound and the specific frequency, respectively, of the conductor of sound (for in-

stance, of the tissue of the lung) are of a higher pitch than all the partial tones of the sound to be conducted.

"2. If partial tones of the sound to be conducted are higher pitched than the specific sound of the conductor, they will be considerably weakened.

"3. If some are lower they will be conducted correctly.

"4. If a partial tone of the sound to be conducted and the specific sound of the conductor attune in their pitch of tone (frequency per second) resonance may result."

Some sounds are transmitted through the chest better than others. This is because between the interior of the air passages and the chest surface different frequencies, even with the same initial intensity, are likely to be affected unequally. It has been suggested that the higher-pitched sounds may be absorbed by resonance, within the air spaces of the lung.

The sounds conducted through the chest to the ear of the examiner depend upon the character of the tissues and their effect on four acoustic factors.

Diffusion—loss of intensity due to conduction over a wide area. In spreading from a sphere to one double its size, the intensity of sound on the surface of the second sphere will be halved. The function of the stethoscope is to diminish diffusion. Diffusion is probably the most important factor in reducing the intensity of sound over the chest.

Absorption—conversion of sound into heat. Plays little part in chest acoustics.

Reflection—sound waves may be reflected backward in the direction from which they came.

Resonance—tone reinforcement caused by amplifying vibrations set up in the second medium so that the two vibrate in unison and produce louder sounds.

References

The account of the acoustics of physical diagnosis which I have given above is derived from numerous articles and sources. To have given credit at every point would have unnecessarily interrupted the argument, but I append below my source material with the recommendation that the advanced student will go over all of it carefully in the original form.

General

Chapters on Sound in any college text on Physics

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Part 3

ANATOMIC REGIONS

Chapter 5

THE BODY AS A WHOLE

1. Temperature, Pulse, Respiration, Chills, Sweats

"Is this patient functionally or organically ill?" "How ill is this patient?"

These are the first fundamental questions which come to the physician's mind when he sees a patient, no matter whether he is seeing him for the first time or whether he is seeing a familiar patient in a new illness.

There are no criteria more fundamentally important in coming to these decisions than the temperature, pulse, and respiration. They are all general functions of the entire body, they are all very sensitive to bodily changes, and there is the advantage that they can be determined quickly and accurately.

The pulse is discussed in detail on p. 304 in so far as it is indicative of local disease in the cardiovascular system. What the physician wants to know in connection with the general condition of the patient is the rate of the pulse, its strength, its regularity—whether it indicates shock, the effect of strong stimulation, or toxicity. It is not necessary to elaborate this theme further. The figure of the physician, watch in hand, counting the pulse, represents the climax of four thousand years of carefully accumulated medical science.

Respiration is not so easily affected, but has correspondingly more significance when it is. The sighing respiration of hemorrhage, the anxious breathing of shock, the rapid breathing of beginning pneumonia and other infections, the air hunger of diabetes acidosis, even when observed in slight degree, carry profound messages.

Hippocratic or Cheyne-Stokes breathing is of grave prognostic import, signifying a disturbance in the oxygenation of the respiratory center in the medulla. It consists in alternating periods of deep, rapid breathing with periods of complete suspension of respiration. Hippocrates described it in the case of "Philiseus, who lived by the wall" (*Epidemics*, Book I, Section 3) as "The respiration throughout like that of a man recollecting himself and rare and large." Cheyne (*Dublin Hospital Reports*, 1818) wrote: "His breathing was irregular: it would entirely cease for a quarter of a minute, then it would become perceptible though very low, then by degrees heaving and quick, and then it would gradually cease again." Stokes (*Dublin Quarterly Journal of Medical Science*, 1846) wrote: "It consists of a series of inspirations increasing to a maximum, then declining in force and strength, until a state of apparent apnea is established."

Biot's breathing, which is seen in meningitis and encephalitis, was described by him (*Lyon Medical*, 1876) as: "This irregularity of the respiratory movements is not periodic, sometimes slow, sometimes rapid, sometimes superficial, sometimes deep, but without any constant relation of succession between the two types, with pauses following irregular intervals, preceded and often followed by a sign more or less prolonged." Conner (*Biot's Breathing*, *Am. J. M. Sc.* 141: No. 3, March, 1911) characterizes this respiration as having (1) periods of apnea, varying in length and occurring at irregular intervals, (2) constant irregularity in rhythm, (3) frequent occurrence of deep signs, and (4) constant uniformity of the expiratory level. While Biot described it only in meningitis, Conner found it in many cerebral conditions.

Temperature.—The body maintains, under the most varied circumstances of external environment, a remarkably constant temperature of 98.6° Fahrenheit by mouth and 99° Fahrenheit by rectum. The external skin temperature, especially of the extremities, may vary somewhat, but the mouth and rectal figures are so rigid that any variation from these is a signal that something is wrong. (British and American temperatures are measured in Fahrenheit, although everywhere else in the civilized world Centigrade figures are used.)

On delicately calibrated thermometers the body temperature in health does indeed show a twenty-four hour swing, lowest in the early morning hours and highest in the late afternoon, but the range is too small to be clinically significant. Children notoriously are more likely to have the body temperature upset than adults.

Subnormal temperatures are found in elderly patients, those with low vitality and those with debilitating diseases, such as cardiac failure.

Fever occurs most frequently as the result of infection. Four types of fever constitute the main groups:

(1) Continuous fever, when the fever does not touch the normal level for days, rises gradually and falls gradually by lysis; the typical example is typhoid fever.

(2) Continuous fever, rising fulminantly and falling abruptly by crisis, the typical example being pneumonia.

(3) A daily variation—low in the morning, high in the evening; typical examples are sepsis and tuberculosis.

(4) Remittent or intermittent fever in which exacerbations occur every few days, the intervening days showing normal or almost normal temperature. Typical are malaria and relapsing fever; in the latter the fever bouts occur about once a week. Many exanthemata, notably smallpox, show an initial fever, a fall when the eruption occurs, and then a secondary rise.

Diseases which are not infectious in which fever may occur are thrombosis (cardiac or cerebral), sunstroke, hyperthyroidism, cancer, Hodgkin's disease, and the neuroses. In none of these (except sunstroke) is fever quite as regular a phenomenon as in infection.

The fever of Hodgkin's disease is a quite regular accompaniment, but it occurs in many forms. (This association has been used as an argument for the tuberculous nature of Hodgkin's disease.) It may be mild, up to 100° F.

and not constant, or it may reach 104° F., and hang on for weeks and months. It may disappear entirely for long periods. The most regular type is the Pel-Ebstein fever (Pel: Berl. klin. Wehnschr. 24: 644, 1887, and Ebstein: Berl. klin. Wehnschr. 24: 565, 1887). This is a remittent fever with long swings of febrile alternating with afebrile, periods. The fever gradually rises and for a week or more stays as high as 104° or 105° F., then gradually subsides and the afebrile period will go on for several weeks, succeeded again by a recurrence of the fever. (See Lemon, W. S.: Am. J. M. Sc. 167: 178, 1924)

Fever as a symptom of visceral cancer was described by Wunderlich. It occurs in carcinoma of the stomach, very frequently in liver metastases and in bronchogenic carcinoma. Its importance from a diagnostic standpoint lies in the possibility that such a condition as an abdominal mass or an atelectasis might be mistaken for an infection or abscess.

Psychogenic fever in hysterical and psychoneurotic persons has frequently been reported and some are certainly genuine. Malingering, as by a patient concealing a hot water bottle in bed and sneaking the thermometer bolt against it, must be remembered when dealing with such cases. (See Falcon, Lesses and Proger: New England J. M. 202: No. 21, Nov. 20, 1930.)

Chills and sweats are regular accompaniments of fever. Some febrile diseases have a particular predilection for these signs. Pneumonia, for instance, is regularly ushered in by a chill, while chills are almost unknown in typhoid fever. Malaria is notoriously "chills and fever." The sweats of tuberculosis and puerperal sepsis are equally notorious. (See Perera: Clinical and Physiologic Characteristics of Chill, Arch. Int. Med. 68: 241, Aug., 1941.)

2. Weight and Height

Standard norms for height and weight are as follows:

The accompanying table gives some of the results of this experience:

CAUSES OF DEATH	OVER-WEIGHTS	UNDER-WEIGHTS	GENERAL EXPERIENCE
General acute infectious diseases	9.67	9.28	8.90
General chronic infections, notably tuberculosis	2.93	16.98	12.42
Diabetes	3.40	0.65	1.25
Cancer	4.40	5.57	4.18
Cerebral hemorrhage	14.14	8.47	12.32
Heart disease	16.01	11.69	11.85
Cirrhosis of the liver	3.47	0.65	1.00
Nephritis	11.07	5.30	6.66

While these are only averages based on many computations, the experience of life insurance companies indicates that deviation of 20 per cent from the standard weight carries definite implications as to longevity and disease incidence. A man of 65 years, 5 feet, 11 inches tall has a standard weight of 180 pounds. At 216 pounds he is 20 per cent overweight, and at 234 pounds he is 30 per cent overweight. Taking a large group of such individuals weighing between 216 and 234, it is found that the death rate among them is 126 as against an expected rate of 100.

It will thus be seen that overweight and underweight carry implications to the diagnostician's mind. They are not exactly definite, but they point the way for more minute examination. And, be it noted, the figures given in Table I are for deaths because, of course, this lends itself to exact calculation. How much wider is the field when we consider the extent to which such chronic illnesses as go under the names of *dyspepsia*, *fatigue*, *neurasthenia*, *arthralgia*, *bronchitis* are associated with or directly attributable to overweight or underweight. Body weight is a simple measurement of extreme importance in clinical medicine. An individual who presents a marked variation in body weight should demand a rational explanation for this alteration. Abrupt gain or loss of weight may be explained in certain instances on a physiologic basis, but it is more likely to be associated with disease. (See Symonds: *The Influence of Overweight and Underweight on Vitality*, Med. Record 74: No. 10, Sept. 5, 1908, and du Bray: *Body Weight in Relation to Health and Disease*, Am. J. M. Sc. 170: No. 4, Oct., 1925.)

3. Posture

Posture has been the subject of many studies which attempt to relate it to different health states. Some, indeed, have made of it a kind of gospel. It is related to body types and constitutional tendencies (see below) undoubtedly, but aside from that I have never been impressed with the value of its practical applications. A person with a flat chest and sagging belly obviously has not the same vigor as an erect athlete with strong abdominal muscles, but one knows many round-shouldered and pot-bellied persons who enjoy the best of health. The following references will inform anyone who wishes to pursue the subject:

Dickinson and Truslow: *Attitude in Relation to Pain*, J. A. M. A. 59: No. 24, Dec. 14, 1912.

Goldthwaite: *An Anatomic and Mechanistic Conception of Disease*, Boston M. & S. J., June, 1915.

Goldthwaite: *The Relation of Posture to Human Efficiency*, Tr. American Orthopedic Association, 1909.

Mills: *Relation of Bodily Habitus to Visceral Form, Tonus and Motility*, Am. J. Roentgenol., April, 1917.

4. Stature

Endocrine dwarfism and giantism are considered in the section on endocrine disorders.

Aside from these forms, stature has little diagnostic significance. Giants and dwarfs are medical curiosities but in most cases that is about all. Rickets, congenital heart disease, and mitral disease produce dwarfism occasionally.

The rate of growth alone is accepted by some pediatricians as an indication of general health. This criterion, however, often needs common sense interpretation. School nurses and social workers may make a family's life a burden by insisting that a child grow according to plan. I once had as patients an immigrant Jewish family whose children were constantly being sent to me by the school authorities because they didn't grow. I never could find anything the matter with them and patiently continued to write letters to this effect when I returned them to their studies. Finally the entire family

—father, mother, grandparents and children—assembled in my office and lined up at the edge of my desk. None of the adults was barely over five feet tall. The exasperated mother screeched at me, “Doctor, look at us! Vat do dey expect—rats from mice?”

The tallest person on record was probably the Alton, Illinois, giant who was carefully measured by Dr. C. D. Humbert in 1937, and found to be 8 feet, 3¼ inches, but he grew over a foot before his death. His aversion to publicity and refusal to be examined prevent us from records later than Humbert’s (*J. A. M. A.* 108: No. 7, Feb. 13, 1927). His growth record by years was as follows:

BIRTHDAY YEARS	HEIGHT CM.
9	185
10	193
11	201
12	209
13	218
14	225
15	232
16	239
17	245
18	251

Most giants are surly, stupid, and uncooperative. Bassoe was not allowed to measure a giant even after death. Humbert (*South. M. J.* 31: No. 9, Sept., 1938), however, described one 7 feet, 6¾ inches, who was alert, intelligent, well read, affable and friendly, and who permitted complete anthropometric measurements. Gray’s article (*Ann. Int. Med.* 10: No. 11, May, 1937) contains detailed anthropometric studies of all known giants and a complete bibliography. (See Werner: *Dwarfism*, *J. Missouri M. A.* 38: No. 3, March, 1941.)

5. Contour

Body contour is modified by disease of the bones, of the nervous system, and by disorders of metabolism. The contour gives a hint that the examination should be concentrated on some particular spot or system, as for instance the spine, the hip, the muscular tonus of some muscle groups (anterior poliomyelitis or myasthenia gravis).

Lipomatosis, defined as localized distribution of fat rather than generalized obesity may markedly, even grotesquely, affect the body contour. Several varieties may be distinguished:

(a) Nodular lipomatosis, consisting of multiple or single encapsulated lipomata.

(b) Diffuse symmetrical lipomatosis. These fatty masses are not encapsulated. They may appear around the neck, or over the shoulders and down the arms.

(c) Adiposis dolorosa (Dercum’s disease). Deposits of fat which are symmetrical, localized, tender, painful, of fairly rapid appearance, accompanied by asthenia, usually occurring in women at the time of the menopause.

(d) *Lipodystrophia progressiva* consists in a marked and disfiguring emaciation of the upper part of the body with a bizarre obesity of the lower part of the body. It affects girls almost universally, and begins in childhood. It does not affect the general health, although naturally it leads to neurosis from sensitiveness as to personal appearance.

The following nutritional conditions produce unnatural body contour by deforming the bones:

Rickets affects infants at the period when rapid growth is taking place. The deformities are (1) *craniotabes*, which produces very prominent eminences of the frontal and parietal bones; (2) *thoracic*, with the rachitic rosary and flaring of the lower margins of the ribs; (3) deformities of the arms at the epiphyseal sites; (4) of the legs with curving of the femur, tibia and fibula, producing knock-knees, bowlegs, saber tibia, coxa vara, and (5) *kyphosis* or *scoliosis* or both.

Osteomalacia occurs with great preponderance in pregnant women with vitamin D deficiency. The pelvis, thorax, spine, and long bones are deformed in a bizarre fashion, when the disease progresses to its final stages, with osteoporosis and decalcification.

Osteitis fibrosa cystica is due to hyperparathyroidism and is described in the section on diseases of the endocrine glands, pp. --?.

Hypertrophic pulmonary osteo-arthritis affects usually only the ends of the phalanges with clubbing of fingers and toes, but may go on to involve the long bones, in fact all the bones. There is an abnormal deposit of calcium, with proliferation of the inner layer of the periosteum.

Osteitis deformans (Paget's disease) occurs preponderantly in late middle or early old age. Males and females are afflicted in about equal ratio. There is hypertrophy of the bones, especially of the skull and legs, resulting in the square, large, calvarium and development of extreme bowlegs. The stature is shortened. After the skull and legs, the pelvis, spine, and humerus are most frequently involved.

Fragilitas ossium is a rare, congenital condition, producing softening of the bones of the skull and long bones. The patient usually sustains numerous pathologic fractures, resulting in very severe deformities. Blue sclera and otosclerosis are parts of the entire picture.

Nutrition.—It comes to be instinctive with the clinician to assess the nutrition of his patient, not only on the first examination, but from week to week and in some cases almost from day to day. He does this by appearance, really a combination of his judgment of the weight, the skin (pallor, etc.), attitude, mental state (apathy), muscular tonus, inquiries as to appetite, etc.

The extremes of pathologic nutrition are obesity and emaciation.

Obesity is of various grades. The 20 or 30 per cent overweight calculated on the standard life insurance scale is a result of overeating, the onset of middle age, with unconscious reduction in activities and a constitution of the pyknic, lateral, mesomorphic type.

Extreme cases of obesity have been recorded by many careful investigators. Willoughby (*Human Biology* 14: No. 2, May, 1942) claims to have

studied the heaviest human being on record in relation to her body build in dex, which means relation of height and girth.

His subject, Mrs. P., weighs 350.4 kg. (772.5 pounds) and is 166.4 cm (67.5 inches or 5 feet, 7½ inches) in height. Her nearest possible competition was a colored woman, quoted by Gould and Pyle, who weighed 850 pounds, but the height is not recorded.

Mrs. P.'s daily life is described by Willoughby. It is surprising that she is able to move at all, since any movement with ordinary muscles becomes a feat of strength. But she does manage to walk over the grounds of her estate daily by resting at intervals. It is stated that she eats only about half the amount an ordinary person eats, but it is evident no careful weighing of food or metabolic experiments were performed. All of her immediate ancestors were overweight, her mother extremely so.

Humberd's patient (Humberd: *Extreme Obesity*, J. Missouri M. A. 33: No. 7, July, 1936) weighed 570 pounds at his peak. He came from a family notable for gross overweight: his paternal grandmother weighed 365 pounds, a sister weighed 225 pounds. He was plump at birth. He had an enormous appetite which he indulged fully, especially with candy and ice cream. His regular defecation was three or four watery stools daily. His chest circumference was 59½ inches, abdomen, 68½ inches. His blood sugar usually ran about 110. His fat was evenly, regularly, and symmetrically distributed. His penis was infantile and no testes could be palpated in the scrotum. Thyroid extract did not affect his weight whatever, only gave him palpitation. He died at the age of 36 of purpura hemorrhagica.

While many observers feel that in the extreme types of obesity the hypophysis and gonads have a lowered activity, there is a well-entrenched school which believes that all obesity is exogenous. Thyroid has influence on some of these patients, but its effect is therapeutic and not of the replacement kind. The fact that basal metabolism is normal and these subjects are mentally alert in most instances would seem to rule out thyroid participation.

Behnke, Feen, and Welham (J. A. M. A. 118: No. 7, Feb. 14, 1942) have proposed an index of obesity based on specific gravity of the body. Low specific gravity is characteristic of obesity and high specific gravity of leanness. The values of specific gravity of healthy men fall between 1.021 and 1.097. The chest circumference of the obese tends to be equal to or smaller than the abdomen, while in the lean the abdomen is notably smaller.

Simmond's disease or hypophyseal cachexia is extreme emaciation caused by sclerosis or necrosis of the anterior pituitary cells. It is described fully on p. 223.

Anorexia nervosa is a state of extreme emaciation described by Gull in 1868 (Lancet, August) and again in 1874. (Clin. Soc. Transactions, VII, 1874. Reprinted in the volume of "The Writings of Sir William Gull," New Sydenham Society.) All the cases described, so far as I know, have been females, usually young, shortly after the onset of menstruation, almost invariably under thirty. The onset is precipitated by an emotional conflict which results

in the patient's refusal to eat, or at least to eat adequately. The weight loss becomes extreme; vomiting is frequent. At the same time there is a motor restlessness and activity, remarkable in a person as emaciated and weak as these patients are. Gull emphasized this and it has been recorded over and over since. There is usually amenorrhea. The basal metabolism is low. The blood sugar tolerance is low in most cases, but in others it is the type of curve seen in healthy individuals who have been starved a few days; i.e., the curve begins at a low level and gradually rises to 170 or 200 mg. per 100 c.c. It has often been postulated that anorexia nervosa is a form of hypophyseal cachexia, but the consensus of the best clinical opinion today is that it is a neurosis. The fact that the patients recover promptly on forced feeding and psychotherapy is in marked contrast to the unfavorable therapeutic response and high death rate of Simmond's disease.

Farquharson and Hyland: *Anorexia Nervosa*, J. A. M. A. 111: No. 2, Sept., 1938.

Magendantz and Prozer: *Anorexia Nervosa or Hypopituitarism?* J. A. M. A. 114: No. 20, May 18, 1940.

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Moulton: *Psychosomatic Study of Anorexia Nervosa*, Psychosom. Med. 4: No. 1, Jan., 1942.

McCullagh and Tupper: *Anorexia Nervosa*, Ann. Int. Med. 14: No. 5, Nov., 1940.

Progressive muscular atrophy of the so-called *Aran-Duchenne type* produces extreme generalized emaciation due to muscle wasting. There is a progressive pigmentary sclerosis of spinal cord anterior horn cells. The muscles show secondary degeneration. It occurs between the twenty-fifth and forty-fifth years, preponderantly in males. The onset is insidious. Usually the muscles of the hands waste first, then gradually the arm, shoulder and pectoral muscles, then all the muscles of the body.

The rarer *Werding-Hoffmann type* appears at an early age and goes to a fatal termination within six years.

Androgyny (maleness within the female and femaleness within the male).—Morphologically the striking differences between the sexes consist of—*male*, silhouette angular, rectilinearity, longer arms, narrow pelvis, lower extremities straight or slightly bowed at the knee, space between the legs when the heels are approximated extends to most of upper leg. *Female*—curving ovoid, narrow shoulders, wide pelvis, arms do not hang from acromial point, extend the neck-shoulder modeling, space between the legs only in lower legs, the inside of the thighs approximating. With these there goes susceptibility to diseases on a sex basis, as may be seen by examining the graph taken from Draper (*The Mosaic of Androgyny*, New England J. Med. 225: No. 11, Sept. 11, 1941).

Deficiency States.—Vitamin or mineral deficiency need not necessarily affect the general nutrition, or at least need not affect the appearance of the patient from the standpoint of general nutrition. Vitamin lack affects the skin, the mucous membranes, the blood, the bones, the nervous system, and the musculature predominantly. Thus the skin lesions of vitamin A deficiency

and pellagra, the mucous membrane and tongue lesions of ariboflavinosis, the hemorrhages of scurvy, the neuritis of beriberi, the bony changes of rickets are described elsewhere.

Besides these classical syndromes, it is suggested that most instances of vitamin deficiency, especially the mild states, are evidences of multiple vitamin deficiency. These patients have a history of food habits consisting of excessive use of refined carbohydrates, suboptimal amounts of fats, and deficient protein. An early symptom is anorexia, which adds a factor in pro-

IMPORTANT SYMPTOMS AND SIGNS

VAGOTONIC SYMPTOMS AND SIGNS	SYPHATICOTONIC SYMPTOMS AND SIGNS
1. Myosis.	1. Mydriasis.
2. Accommodation spasm.	2. Paralysis of accommodation.
3. Epiphora.	3. Dryness of eyeballs.
4. Hyperhidrosis.	4. Dryness of skin.
5. Frequency of winking.	5. Infrequency of winking (Dalrymple's sign).
6. Salivation with constant spitting.	6. Dryness of mouth.
7. Hyperacidity of stomach contents.	7. Low gastric acidity.
8. Arrest of secretion of gastric glands (achylia).	8. Increased gastric secretion (gastroe-corrhea).
9. Hypermotility of stomach and intestines.	9. Lessened intestinal tonus.
10. Vomiting.	
11. Diarrhea (8 to 10 times daily).	11. Constipation.
12. Spastic colon.	
	13. Faulty convergence of eyes (Mobius' sign).
14. Biliary colic (inhibited by atropine).	
	15. Wide eye slits.
16. Exophthalmos.	16. Exophthalmos.
17. Bradycardia.	17. Tachycardia.
18. Low blood pressure.	18. High blood pressure.
	19. Vasoconstriction, as seen in (a) peripheral anemias, (b) intermittent claudication, etc.
20. Pollakiuria.	20. Relaxation of detrusor of bladder (incontinence).
	21. Urticaria.
22. Asthmatic attacks.	
23. Esophagism.	23. Atony of stomach.
24. Mucous colitis (analogue of bronchial asthma).	26. Gastroptosis.
25. Gastropasm and pylorospasm.	27. No dermatographia.
27. Dermatographia.	28. Tonsils small and atrophic.
28. Outspoken status thymicolymphaticus.	29. Gag reflex marked.
29. Gag reflex almost absent.	30. Eosinopenia.
30. Eosinophilia.	
31. Pulsus irregularis respiratorius which disappears with atropine.	
32. Irregular breathing (disappears with atropine).	32. Tachypnea with dyspnea (not affected by atropine).
33. Clammy hands and feet.	33. Dry hands and feet.
34. Priapism.	
35. Aschner's phenomenon produces slow pulse.	35. Aschner's phenomenon produces no change in pulse.
36. After atropine pressure on eyeballs produces no slowing of pulse.	
37. Increased fat tolerance.	37. Steatorrhea.
38. Increased carbohydrate tolerance before and after epinephrine administration.	38. Lowered carbohydrate tolerance before and after epinephrine administration (i.e., epinephrine hypersensitivity).
39. Pilocarpine causes extreme salivation.	39. Pilocarpine causes no salivation.
	40. Loew's test.

viding inadequate nutrition. There is often gastric achlorhydria. The earliest manifestation of general vitamin deficiency is delay in dark adaptation of vision. The patient looks tired and listless. The skin is scruffy, the gums and tongue are sore. Pyorrhea is frequent. Mental confusion and forgetfulness are evident. Tenderness of the nerve pathways and of the calf muscles, tachycardia and slight edema are other signs reported. Such is the picture as some paint it, but in my experience, the clinician should approach conclusions about avitaminosis with the utmost caution. The descent into Avernus is still the facile path of amateurs.

Assessment of Physiologic Status.—In the days of my youth there was a thesis which suggested that all persons could be classified on the basis of whether their involuntary reactions were dominated by the vagus or the sympathetic nerves. I set myself the task of learning this thoroughly at the time and after twenty-five years of application of it to clinical medicine, I can say with some assurance that I have never found a single instance or situation where it was of the slightest use.

The Grid Technique of Evaluating Physical Fitness.—Wetzel (J. A. M. A. 116: No. 12, March 22, 1941) has developed a method of evaluating physical fitness, especially in children, by regular recording of height and weight and age. These are plotted on a grid in which the ordinate represents height and abscissa represents weight. Age is represented by the oblique progress of the measurements across the grid as the weight and height increase. The method has proved valuable because it really represents the physical status of the child, although only the three simple measurements are recorded. A child's proper development depends upon its proper growth and this depends on its nutrition, food absorption, and underlying general health. Healthy developmental progress continues in an established channel as if this were a preferred path. The grid shows denotations which may lead to investigation which will disclose fundamental infections, metabolic or endocrine disease.

6. Constitution. General Bodily Build

Somatotypes.—Man as a species has physical characteristics which you and I, being one of the symposy, instinctively recognize and classify. From the Andaman Islander with his stunted form and intellect, through the European with average size and mind, to the Mongolian giant we say after the merest glance—A man. But in any group there are variants—the tall, medium, and short, the overweight, average, and underweight, the heavy-set and slender. The combination of these characteristics we may call constitution.

The significance of constitutional types has attracted physicians from the very earliest times. Indeed the ancient writers, Hippocrates and Galen, paid more attention to it than we do—it was the cornerstone of their practice. They founded their doctrine of humors on it—there was the phlegmatic, sanguine, bilious, and melancholic man. And his humor predisposed him—fated him—to certain diseases.

In our time a series of students have been fascinated by this problem—Kretschmer, Bean, Goldthwaite, Bauer, Mill, Draper, Stockard, Pende, di

Giovanni, Graves, Paterson and Skelton, have all contributed philosophies along this line. We glance briefly at one or two such classifications.

Kretschmer (*Körperbau u. Charakter*. Berlin. 1926) divided mankind into two constitutional patterns—the pyknic (πυκνός—compact) and the asthenic (ἀσθενής—lacking force). Later he added a medium athletic type. Kretschmer was more interested in the mental and personality types that went with these bodily forms than in the physical syndromes.

Goldthwaite (An Anatomic and Mechanistic Conception of Disease, Boston M. & S. J., 1915) called similar types herbivorous and carnivorous.

Mill (The Relation of Bodily Habitus to Visceral Form, Tonus and Motility, Am. J. Roentgenol., 1917) was content to call them linear and lateral. He was the first of the students of the subjects to prove that the form and position of various viscera are different in the two forms in life.

W. H. Sheldon is the last investigator to attack the subject (Sheldon, Stevens and Tucker, *The Varieties of Human Physique*, New York, 1940, Harper & Brothers, and Sheldon and Stevens, *The Varieties of Temperament*, 1942, Harper & Brothers).

Sheldon and his co-workers were the first—and herein lies his most important contribution—to establish external bodily measurements in order to determine these types. His predecessors arrived at a kind of temperamental judgment and labelled them linear and lateral, herbivorous and carnivorous, pyknic and asthenic, without any very definite standards (Mills came closer than the others to standards, however). Space will not permit the inclusion of these measurements in this work: the interested reader is referred to the original, easily available literature.

Sheldon classified mankind into three constitutional types, the ectomorph, the mesomorph, and the endomorph, corresponding to the predominance of the organs originating from the three germ layers.

Various components enter into the determination of any individual's type—heredity, sex and the dominance of sexual traits, endocrine activity, and, to a much less and more debatable extent, climate, environment and training (as, for instance, training influences posture). The last, as I say, are debatable—no amount of athletic training will make an ectomorph into a mesomorph, but it may push him into the borderline class. “There’s a divinity that shapes our ends, rough-hew them how we will.”

“*Endomorphy* means relative predominance of soft roundness throughout the various regions of the body. When endomorphy is dominant, the digestive viscera are massive and tend relatively to dominate the bodily economy. The digestive viscera are derived principally from the endodermal embryonic layer.

“*Mesomorphy* means relative predominance of muscle, bone and connective tissue. The mesomorphic physique is normally heavy, hard and rectangular in outline. Bone and muscle are prominent and the skin is made thick by a heavy underlying connective tissue. The entire bodily economy is dominated relatively by tissues derived from the mesodermal embryonic layer.

“*Ectomorphy* means relative predominance of linearity and fragility. In proportion to his mass the ectomorph has the greatest surface area and hence

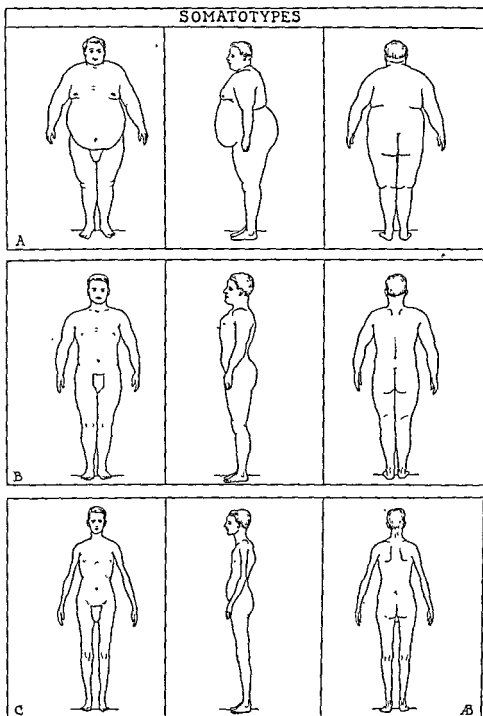


Fig. 8.—Somatotypes. A, endomorphy; B, mesomorphy; C, ectomorphy. (After Sheldon, Stevens, and Tucker: *The Varieties of Human Physique*, New York, 1940, Harper & Brothers.

the relatively greatest sensory exposure to the outside world. Relative to his mass he has also the largest brain and central nervous system. In a sense, therefore, his bodily economy is relatively dominated by tissues derived from the ectodermal embryonic layer." (Sheldon, Stevens and Tucker.)

No one, of course, claims that these categories are rigid—that every human being fits neatly into one or the other. There are borderline cases and variants, and, indeed, these make up a larger majority than the typical and extreme examples.

What is the clinical significance of these observations? Do they help in practical diagnosis? Dr. George Draper used to hold a clinic in which he started not with the symptoms, but with the patient's anthropologic measurements, and he posed the question not, "What is the disease this patient has?" but, "What disease should he have, considering his architecture?" But what is possible to a genius like Dr. Draper is not within the compass of ordinary men. If I have a patient in whom I have arrived at the diagnosis of peptic ulcer, do I say, "This man is a mesomorph and mesomorphs do not have ulcer"? No, I am afraid I do not.

In short, while the whole subject is theoretically interesting, I cannot say that I apply it to any extent in practical diagnostic work—at least of organic diseases.

In functional diseases, the neuroses, it is important to know what sort of a person the disease has as well as what sort of a disease the person has. Here we enter the field of psychosomatic medicine which has been defined as "that part of medicine which is concerned with an appraisal of both the emotional and the physical mechanisms involved in the disease processes of the individual patient with particular emphasis on the influence that these two factors exert on each other and on the individual as a whole."

But these considerations are valuable more for therapeutics than for diagnosis, and with therapeutics this treatise does not deal. Even so, I am far from convinced that a person's morphology destines him to certain definite life activities. The endomorph is not necessarily preoccupied all his life with viscerotonic urges, nor the mesomorph with somatonic, nor the ectomorph with cerebrotonic activities. To take some historical illustrations, Browning was a mesomorph, yet he wrote as delicate poetry as such ectomorphs as Shelley and Tennyson; Franklin Roosevelt was an ectomorph, Winston Churchill an endomorph, Hitler was an ectomorph, Mussolini a mesomorph, but they carry on similar activities with about equal interest and skill: such military commanders as Frederick the Great and Wellington, both ectomorphs, achieved equal strategical success as such a mesomorph as U. S. Grant and such an endomorph as R. E. Lee.

Somato-typing is a fascinating bypath of medical science, but do not let its study lead you into intellectual quicksands.

Constitutional Inadequacy.—While the study of bodily types is perennially fascinating, critical review of one's clinical experience hardly confirms the belief that it is of great value in practical diagnosis. More valuable is the

conception of constitutional inadequacy which is partly based upon bodily build, partly on heredity, and partly on physiologic tonus.

Constitutional inadequacy is well defined by its name. It applies to individuals who are inadequate to the sustained performance of the ordinary duties of life. This inadequacy is constitutional because it is imbedded in their bodies and physiologic responses and not due to environment nor to any experiences, although crises may be precipitated by experiences, ranging from disappointment in love or the prospect of extra work to physical trauma. It is not the same as neurasthenia, because the conception of neurasthenia was that the nerve cells became worn out from too much effort and work: the constitutionally inadequate person does not wear himself out with work, because he doesn't do any work; he is born tired. The terms "constitutionally psychopathic personality," "asthenia," "psychasthenia" have all been proposed for this group but in my opinion no term is so comprehensive and specifically descriptive as constitutional inadequacy.

They constitute a very important group of patients. In the first place, they are the largest group, numerically, of any group of chronic invalids. Important also, because they are so generally misunderstood. The medical profession as a whole is inclined to be mechanistic minded: a mechanistic explanation of a clinical problem is so much easier to deal with than a psychological or personality explanation. So these patients wander around from clinic to clinic, from specialist to specialist, getting nasal septa straightened, spectacles fitted, submitting to laparotomies, colonic flushings, courses of massage, electrotherapy, wearing braces, corsets, special shoes and all the abracadabra of therapeutics. "Commonest among the diagnoses made nowadays in the hope of explaining the sufferings of these people," writes Alvarez (*J. A. M. A.* 119: No. 10, July 14, 1942), "are colitis, spastic colon, ptosis, pelvic disease, adhesions, chronic appendicitis, glandular dysfunction, low blood pressure, mild Addison's disease, low blood calcium, brucellosis and chronic nervous exhaustion.* I gain the disquieting impression that we physicians, in our desperate efforts to find some one bit of diseased tissue on which to place the blame are only grasping at straws. Again and again we pounce hopefully on some slight bodily peculiarity and try to correct it, only to realize after a fruitless operation or months of ineffectual treatment that we are on the wrong track."

The proper procedure, of course, is to handle them by psychotherapy and a sympathetic review of their life history. This is time-consuming and boring work, and in most cases as unsuccessful as the mechanistic procedures, but at least if you do it you won't have anything on your conscience.

The diagnosis usually is easy once you have the condition well focused. The bodily build is usually the asthenic, linear, ptotic type with long, thin, inadequate muscles, a constitutionally inferior digestive system anatomically, low blood pressure, perhaps evidence of childhood tuberculosis, poor posture and a sagging spine without the anatomical curves. The history is a long recital of frustrations which seem petty to the normal personality.

*I would add vitamin deficiency and spondylitis. L. C.

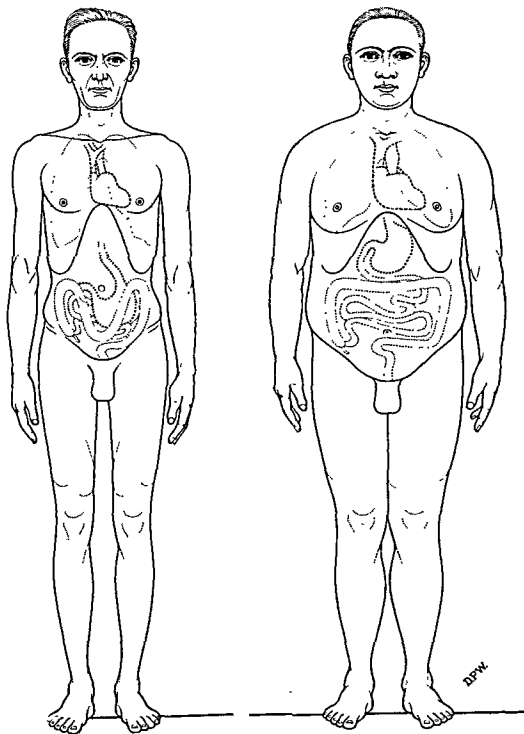


Fig. 9.—Linear and lateral types of physique.

Diagnostic difficulties come when the picture is incomplete, or when it occurs in the person of a well-muscled apparently strong mesomatic type of individual, or when it occurs as the background of an actual organic illness, or in children. The big, strong, adequately nourished man or woman may disclose the familiar history of many periods of illness and, as Alvarez says, a member of the family may give the hint by saying, "Dad may look big and strong, but let him get a pimple on his nose and he'll be laid up for two weeks." One of these patients may actually have a duodenal ulcer, gallstones, or arteriosclerosis, but the speeter of constitutional inadequacy really dominates the background of the illness. And remember, the curtain on the tragedy goes up in childhood and the poor child has to submit to tonsillectomies and turbinectomies and spectacles and heaven knows what else in order to carry on the burdens of common school, dancing school, Sunday school, violin lessons, campfire activities, boy scouting, and various kinds of youth rallies.

The asthenic syndrome, as outlined by Bortz and Pierral* (Ann. Int.-Med. 6: No. 3, Sept., 1932), is:

1. Muscular asthenia—weakness of both smooth and striated muscles.
2. Intellectual asthenia—prostration under prolonged intellectual concentration.
3. Emotional tendencies—two types—(a) the calm, resigned type; (b) disposition to "unnerving," irritability, constant need for change.
4. Nervous symptoms—headache very frequent, dizziness, insomnia (of a peculiar type—goes to sleep readily and wakes in three or four hours and can sleep no more), lumbago, eyestrain.
5. Visceral asthenia.
 - A. Digestive symptoms—these are most frequent and prominent. Practically all dyspeptics belong to this class. Constipation, anorexia, feeling of heaviness and bloating after meals, abdominal pains typical (of organic disease) and atypical, mucous colitis, belching and aerophagia, difficulty of swallowing, food idiosyncrasies.
 - B. Circulatory asthenia—palpitation, tachycardia, frequent blushing.
 - C. Genital asthenia.
 - D. Endocrine asthenia.
6. Subjects are sensitive to the action of drugs.

II. THE SKIN

"The skin is the mirror of the system," was the sage and poetical pronouncement of Martin Engman. It reflects not only the deep tides of organic disease, but the storms of the soul, the momentary physiologic changes of arterial spasm and relaxation. The great school of von Hebra founded dermatology on the basis of local pathology—on the conception that all skin lesions were confined to the skin alone. With the accumulation of biochemical and biophysical knowledge of the skin's function, we have come around to the conception that hardly any disease of the skin is local, nearly all are part of a systemic process.

How much should the internist know about the skin? If the above statements are true, if the dermatologist is "the internist of the skin," may we not

*I have modified this outline somewhat. L. C.

assume that the internist is "the dermatologist of the internal organs"! The more he knows about the skin the better. It is, however, as we all realize, a field in which long practice and experience sharpen observation and, if available, we should all like to have a dermatologic consultant. What I really mean to ask is: How much on the skin should I put in a book like this? I shall content myself with merely mentioning a short-title catalogue of the suggestions that should run through the internist's mind when confronted with skin lesions in a patient with a general systemic disorder.

1. Hemorrhages.—

A. PETECHIAE.—

Endocarditis.—The small, pinhead-sized, dark red, flea-bite spots probably represent embolic localizations of bacteria. They occur especially on the hands and feet, but may be anywhere—even in the conjunctiva and buccal membrane. They often go and come in crops.

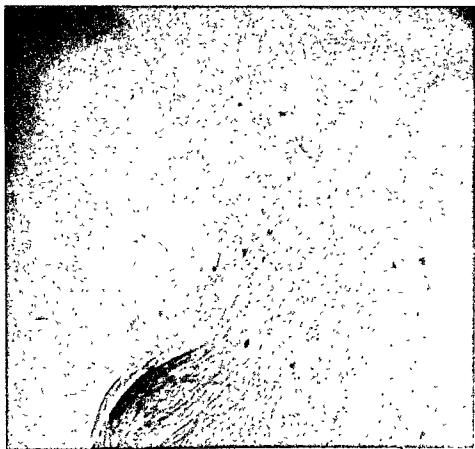


Fig. 10.—Petechial hemorrhage in subacute bacterial endocarditis.

Meningitis.—In meningococcic meningitis petechiae appear in the stage of infection. They are much the same in appearance as those of endocarditis, although in some cases they get as big as a half dollar. They may even go on to

gangrene. They are hemorrhagic and cannot be obliterated by pressure. A prodromal maculopapular rash may precede them. The petechiae appear before the end of the first twenty-four hours of infection. The rash is often sparse and may be overlooked. The ankles and wrists are the favorite locations when the rash is not generalized. The rash reaches its full development within a few hours and fades rapidly. The petechiae are from 1 to 3 mm. in diameter. The rash is an early sign and if recognized leads to early and, therefore, effective therapy. Severe generalized headache comes on early, about concomitant with the rash. The two things together indicate a lumbar puncture. (See Strong: Recognition of Meningococcic Infections, Am. J. M. Sc. 206: 561, Nov., 1943.)

Meningococcemia, independent of meningitis, may run a prolonged (2 to 11 weeks) fever with a polymorphous rash (petechiae, papules, purpura), generalized aches and pains, and chills and headache. (Campbell: Am. J. M. Sc. 206: 566, Nov., 1943.)

Rocky Mountain Spotted Fever.—The characteristic petechial eruption first appears on the wrists and ankles twenty-four to forty-eight hours after onset. It spreads from the original location in a centripetal fashion over the scalp, chest, and abdomen, but is always more marked in the extremities. (See Baker: Rocky Mountain Spotted Fever, Ann. Int. Med. 17: No. 2, Aug., 1942.)

Hemorrhagic or "black" smallpox in which the eruption consists of maculopapular spots into which hemorrhage occurs instead of the familiar vesicles. It has a high mortality.

Measles may also assume a hemorrhagic form, also severe.

B. PURPURA is an extravasation of blood, producing reddish or purplish spots under the skin, usually quite generally distributed (even including the buccal mucosa), ordinarily of about the same size, about that of the head of a tack but sometimes going on to ecchymoses of some size.

They are classified as those cases in which the blood platelets are diminished (thrombocytopenic purpura), which accounts for the tendency to spontaneous hemorrhage; and the cases in which no change in the platelets can be found—idiopathic or purpura simplex.

Thrombocytopenic purpura is an acute or chronic or recurrent condition. There is always a marked diminution in the blood platelets. No good explanation of this decrease can be given. In some cases the megakaryocytes in the marrow are decreased in number. Bleeding time is prolonged. Coagulation time is little, if any, prolonged, but the clot does not retract. In the acute form not only purpuric spots but also hemorrhages from the nose, mouth, uterus, and rectum and into the conjunctivae occur. The chronic form does not necessarily or usually impose itself on the acute form. It is in every way milder, so much so that the patient may take no notice of subcutaneous hemorrhages at the site of slight bruises, small crops of purpura, prolonged menstruation, recurrent nosebleed, etc.

In differential diagnosis aplastic anemia, acute leucemia, hemophilia and bleeding from telangiectasia need cause no worry because of the characteristic blood counts.

Idiopathic purpura occurs in two forms associated with the names of Schönlein (purpura rheumatica) with sudden extravasations into the joints, and of Henoch, with hemorrhages in the gastrointestinal tract with hematemesis and melena, more often merely colic, vomiting, or nausea. Henoch's purpura mimics any acute abdominal crisis and the internist and surgeon should be cautious in making a diagnosis of acute appendicitis in the presence of a purpuric rash.



Fig. 11 —Purpura hemorrhagica.

C. SPONTANEOUS SUBCUTANEOUS HEMORRHAGES are frequent manifestations in *leucemia*.

Scurvy in the early stage is likely to produce ecchymoses at skin points distal to constricting clothing, especially around the hair follicles (piqueté scorbutique). Later large ecchymoses appear, especially over the thigh, and there may be hemorrhages into the muscle masses or subperiosteally.

D. DRUGS.—Hemorrhagic skin lesions, including petechiae and purpura, may be caused by benzol, copaiba, ergot, bromides, iodides, quinine, antipyrine, and salicylates.

X-ray irradiation, when severe, will also produce the same lesions.

2. Capillary Dilatations.—

The vascular spider, or telangiectasia, of cirrhosis is conveniently classified here. Of 63 patients with cirrhosis of the liver, Patek, Post, and Victor (Am. J. M. Sc. 200: No. 3, Sept., 1940) found 48 had vascular spiders. Most of them were found on the face, occasionally on the arms, fingers, and upper trunk. They are not similar to the phlebectasia around the rib line (see p. 291) nor the congenital telangiectasia of Osler (Bull. Johns Hopkins Hosp. 12: 333, 1901) which is characterized by a familial tendency, recurrent nosebleeds in childhood, occurring less frequently in adult life and development of telangiectasis and angiomas in middle life which increase in number with the passing years.

A vascular dilatation on the palms of the hands with an erythema not fading with elevation of the hand is described in 5 of 20 consecutive patients with portal cirrhosis of the liver by Perera (J. A. M. A. 119: No. 17, Aug. 22, 1942).

3. Granulomatous Ulcerative Skin Eruptions.—

A. DUE TO BLOOD OR LYMPHATIC DISEASE.—Hodgkin's disease may present erythematous skin eruptions as the only sign of the disease. These are at first red, raised, irregular nodules which break down in the center, leaving small multiple ulcerations. More common are papules on the trunk or extremities which run an indolent course, occasionally undergoing central necrosis. Histologically, they resemble Hodgkin's lymph nodes. Pruritus is a regular and bitter complaint of the patient with Hodgkin's disease, whether there be any visible eruption to account for it or not.

Leucemia cutis is, aside from the subcutaneous hemorrhages mentioned (see p. 192), a part of lymphatic, not myelogenous leucemia: either an infiltration of lymphatic material or an exfoliative dermatitis. Monocytic leucemia shows large macules which greatly resemble secondary syphilides, but in time turn a slate blue.

B. OF UNKNOWN ETIOLOGY AND NATURE.—

Boeck's sarcoid typically presents nodular grouped superficial subcutaneous granulomatous eruptions with a predilection for the face, arms, shoulders, and trunk.

Disseminated lupus erythematosus (not tuberculous) is a generalized disease with skin lesions that occur in about 75 per cent of cases, consisting of an erythematous rash on the face and upper chest. The distribution of the rash on the face is roughly butterfly-shaped or lupuslike. But lupus is a poor name: the lesions do not resemble lupus. The patches are irregular in shape, fairly discrete with normal patches of skin between. Essentially the pathologic change is vascular in the capillaries, and in the later stages, spots of

telangiectases appear in the midst of the erythema, an evidence of more permanent changes. It is essentially a disease of the capillaries, the most constant manifestation being a polyarthritis. There is a chronic fever, leucopenia, and inflammatory-like deposits in the serous membranes. Bleeding from the nose, gums, and mucous membranes occurs. Splenomegaly is encountered. It runs a long course, terminating fatally. It affects females from the ages of fifteen to thirty preponderantly. Visceral changes consist of adhesive pericarditis, pleuritis, verrucous endocarditis (Libman-Sacks complication), and hemorrhagic nephritis. Histologically nearly all the viscera show vascular lesions in the finer vessels. (Baehr, Klemperer, and Schiffrin: *Trans. A. Am. Physicians* 50: 139, 1935.)

C. DUE TO GENERAL INFECTIONS.—

Glanders occurs exclusively in those who handle cattle and horses. The disease is communicated only by inoculation and therefore appears on surfaces which would come in contact with the infective lesion on the animal, i.e., hands and face. Because of the widespread inspection and eradication of animals with the disease it has become very rare, but there may be a return due to war conditions in disrupted countries such as Russia, China, and Egypt. The acute eruption farcy bud is an infiltrating, ulcerating, malignant granuloma which spreads by lymphatic extension as well as by inoculation. It usually begins on a finger or back of the hand and is conveyed to the face. It particularly has an affinity for the mucous membrane of the nose and a generalized respiratory infection is common. A chronic form also occurs. The final diagnosis is made by agglutination blood tests (1 to 800 is diagnostic), complement fixation, and the skin reaction with mallein.

Anthrax is another disease that is disappearing, but not so completely as glanders (there were 196 cases reported in the United States in 1936-1938). A malignant pustule may crop up any time under most remote circumstances: everyone will remember the Army epidemic of 1917-1918 from shaving brushes. The malignant pustule appears first as a red, raised papule of considerable size; constitutional signs are usually marked from the first. The skin lesion develops rapidly so that a bulla surrounded by intense edema and induration is implanted on the papule. The center sloughs out, appearing as a dark brown or purple eschar surrounded by vesicles and red, hot, or purplish inflammatory area. Regional glands enlarge and frequently suppurate.

Actinomycosis may come to be recognized in many, if not in most, instances only when the lesion emerges on to the skin—in the cervical region (lumpy jaw) from the underlying bone and periosteal disease, in the chest from the pulmonary disease, in the midline of the neck from vertebral disease. There is marked induration and fixation of the skin with a lesion that finally resolves into a discharging ulcer. The ray fungus in the serous discharge can sometimes be distinguished by the eye by its glistening refractile appearance. The skin surrounding the ulcer is very likely to take on a purplish, semi-gangrenous hue.

Blastomycosis is only rarely systemic, usually affecting the lungs alone in the form of multiple pea-sized abscesses. The sputum shows the blastomyces.

In the systemic form, which is a wasting, progressive disease—the skin manifestations come in crops. When the skin alone is affected there are chronic, progressive *granulomata* with thick crusts, warty vegetation, and discharging sinuses. These are usually multiple, spread by auto-inoculation, on the face, hands, neck, groin, etc.

Sporotrichosis usually appears as a string of nodules in the skin and subcutaneous tissues of the hand and arm. Its origin is occupational and traumatic—gardeners, laborers, soil workers. A primary sore on the finger causes a lymphangitis. The nodules, which are painless, soften and discharge. A general disseminated form with symptoms of septicemia is rare.

Tularemia produces a very similar picture to that of *sporotrichosis* in its usual form. It too is occupational in that it occurs in hunters and those who skin and dress rabbits and other small animals. Many of these animals have a generalized form of the disease with multiple abscesses in the liver and spleen. Infection of a finger leads to an ulcerated primary lesion with secondary infection along the lymph nodes. There is also an ocular type, and a generalized (typhoid) type of the disease.

Tuberculosis of the skin is not often associated with the general systemic form of infection. The dermatologist distinguishes *lupus vulgaris*, *tuberculosis verrucosa*, *tuberculosis ulcerosa* and *scrofuloderma* (associated with tuberculous lymphadenitis). Associated with systemic infection are: (1) miliary disseminated papules, (2) the form known as *lichen scrofulosus*, (3) *papulonecrotic*, and (4) *rosacea tuberculids*—all rare.

Leprosy seldom runs its course without skin manifestations. These, however, are so rare in North America and England and so varied in their manifestations that I will refer the reader to the accounts in the texts on dermatology.

Gumma of the skin, and the other late manifestations of syphilis called *rupia*, *discoïd*, *serpiginous*, and *nodular*, may come on any time, as late as twenty years after the secondary eruption. They so often accompany chronic general ill health, which may imitate anything with the syphilitic history well marked, that the internist should always be on the alert for them. In fact, of all the fads and phobias which the general internist is likely to employ to explain patients with chronic illness—calling them *allergy*, *avitaminosis*, *endocrine* or what—the safest is probably to have an obsession about syphilis.

Skin changes, such as “piebald neck” or *leucoderma colli* and thin, wrinkled, wet-cigarette-paper scars, suggest late syphilis.

The commonest sites of the *gumma*, especially the ulcerative *gumma*, are the lower legs, over the *fibula*, the outer arms, over the *ulna*, the face and especially over the *calvarium*, the back, and on the buttock. The commonest sites for the *nodular* (nonulcerative) or *rupial* syphilid are the face, the forearm, the back, but no localization is exempt.

The ten basic physical characteristics of tertiary skin syphilis, as given by Stokes, are (1) solitary character, (2) asymmetry, (3) induration, deep palpable infiltration, (4) indolence, (5) arciform configuration, borders forming segments of circles, (6) sharp margination of lesions, punched out appearance of ulcers, (7) tissue destruction and replacement, with or without ulcer.

ation, (8) tendency to central or one-sided healing, (9) atrophic, noncontractile scar formation, (10) peripheral hyperpigmentation. All, especially (6), (7), and (9) are subject to exceptions.

Differential diagnosis must be made from varicose ulcers, tuberculosis, psoriasis, ringworm, sporotrichosis, and leprosy.

Rheumatic nodules are really subcutaneous, connected with fascia, tendons, periosteum, and fixed to the underlying structure. They occur most often in children as a complication of endocarditis and severe forms of rheumatic infection. The skin is pink or dusky red over them. They are usually not tender. Favorite sites are over the shins and in the Achilles tendon, but they may appear over the spine and flat bones such as the scapula, parietal, frontal, and patella. Erythematous rashes, erythema multiforme, also occur in rheumatism.

Erythema nodosum may easily be mistaken for rheumatic nodules. Indeed, when they occur in the course of rheumatism the differentiation has an academic flavor, consisting in the point that erythema nodosum nodules are painful. Erythema nodosum consists of discrete, firm, hot, tender conical elevated nodules, 1 to 5 cm. in diameter and symmetrically distributed. The favorite sites are over the shins, much less frequently over the forearms, arms, thighs, buttocks, and face. Poppel and Melamed (New England J. Med. 227: No. 9, Aug. 27, 1942) found them associated with generalized systemic disease in all but 15 per cent of a series studied. The associated diseases in order of frequency were respiratory infections, arthralgias, drug ingestion, rheumatic heart disease, tuberculosis, and ulcerative colitis.

D. DRUGS which form granulomatous skin eruptions are the bromides and iodides particularly. Arsenic, chloral, and quinine form ulcerations with gangrene.

4. Erythematous, Macular, Papular, and Pustular Eruptions.—

A. DRUGS.—“Practically all drugs cause erythematous and urticarial eruptions which may be vascular reactions.” (Andrews.)

Phenolphthalein and pyramidon are the two commonly used drugs which cause large macular spots.

Pustular eruptions are caused by bromides and iodides.

Vesicular eruptions are not common from ingested drugs, but frequently from contact.

B. GENERALIZED ERYTHEMA from *polycythemia rubra vera* is a dark red, mixed with a cyanotic color. It is due to the enormous increase in the circulating erythrocytes and the increased viscosity of the blood which cause engorgement of the capillary vessels. There is also engorgement of the sclerae. The face and the fingernails and toenails show the discoloration more than other parts of the body. Vascular accidents which are natural accompaniments of the disease, with thrombosis and embolism, arterial and venous occlusions, lead to many diagnostic mistakes. The proctologist (hemorrhoid), the orthopedist (arthralgia), the neurologist (hemiplegia), or the gastrologist

(gastric hemorrhage) may see the patient first. Haden tells of a patient who had an amputation of the leg for gangrene and came in to have the other leg amputated!

C. INFECTIOUS DISEASES.—The eruptions of measles, German measles, scarlatina, typhoid fever, typhus fever, smallpox, and chicken pox should be familiar to every internist but many anecdotes exist which indicate that they are not. During Army service it was a regular thing to have a medical officer admit a man to a general ward, who turned out next day to be a fully blooming case of smallpox, measles, or scarlatina.

The prodromal period in all of them is troublesome for the diagnostician. and in the case of measles and scarlatina when they occur in adults. I remember an instance when I was serving on the staff of the General Hospital in Kansas City. We had quite an active smallpox service, and one of the secretarial staff had been living and sleeping in the contagious ward. One morning I was asked by the house officer to see her because of an erythematous eruption of a nondescript character. I made the most careful examination of every inch of her body for a poek. This was on Monday. By Wednesday the eruption had gone, she felt well, and asked my permission to visit her family over Thanksgiving. She was gone two weeks and during that time she developed a complete efflorescence of smallpox and triumphantly showed me the scars when she returned. The emphasis of the story should be put on the fact that she was living in the contagious pavilion (I found out later she had never been vaccinated), that I thoroughly suspected something and made a most thorough search for it. Top (*Handbook of Communicable Diseases*, The C. V. Mosby Co., 1941) writes under the heading of smallpox: "Prodromal symptoms continue for two to four days. Occasionally a rash appears during this interval, which is scarlatinal in character and quite fleeting."

Measles.—Classically measles goes through five stages after the incubation period—coryza, fever, conjunctivitis, Koplik's spots, and rash. Classically, these take successively about five days. Note that the rash which the inexperienced practitioner may expect at beginning actually is the last to appear. *When the rash appears, the fever usually subsides and the patient feels better.*

The rash appears first as faint red spots on the face, neck, and behind the ears. Later it covers the chest and rest of the body and becomes increasingly darker in color and macular and maculopapular. Coalescence of the rash appears in some places. By the fifth day from the time of appearance the spots assume a brownish discoloration and then progressively fade.

I say "classically," which would obtain 90 to 95 per cent of the time, though, of course, the schedule may be broken up. The rash may appear early in the midst of the coryzal symptoms. More usual, especially in adults, is for the prodromes to precede the rash by a week or even two weeks.

German measles has a short prodromal period with far less marked catarrhal signs than in measles. The rash may appear on the first day. It appears on the face and neck the first day, on the trunk and upper extremities the next. The eruption consists of light pink macules which in the second day may appear

scarlatinal. Small, shotty lymph nodes behind the ear are particularly helpful in diagnosis, although lymphadenopathy occurs in the neck and occipital areas.

Scarlatina.—The eruption of scarlet fever, according to modern epidemiologic concepts, is a fortuitous circumstance, depending first upon when the strain of streptococcus which invades the throat has an erythrogenic toxin and second, on the state of the infected subject's immunity. "The result in a Dick-negative subject—a host with antitoxic immunity—is a local infection corresponding to sore throat and tonsillitis. A Dick-positive subject, lacking antitoxic immunity, develops the complete syndrome of scarlet fever. Infection with a streptococcus unable to generate rash-producing toxins gives only a localized throat infection, irrespective of whether the host has antitoxic immunity or not." (Gordon: *Current Epidemiological Aspects of Scarlet Fever*, New England J. Med. 221: No. 26, Dec. 28, 1939.)

Scarlet fever begins abruptly with the four cardinal symptoms of fever, headache, vomiting, and sore throat. The tongue is red and the papillae are prominent—strawberry tongue. The rash comes on in one to five days, appearing first on the trunk. The face is flushed, with pallor around the mouth. The older epidemiologists look in the axillae in a suspected case. The rash is generally erythematous with punctate spots the size of goose pimples. It fades on pressure. The erythema or the puncta may, however, appear alone. Peeling occurs as early as the fifth day or as late as three weeks. Absence of peeling does not vitiate the diagnosis. Great variation in severity of a single case or of an epidemic is a characteristic of scarlet fever.

Complications are frequent in scarlet fever, the commonest being lymphadenitis (occasionally suppurative), otitis media, mastoiditis, albuminuria, nephrosis, myocardial weakness, arthritis, and chicken pox.

Typhoid Fever.—The rose spots appear from the seventh to the tenth day on the abdomen and back. They may be few in number or constitute a veritable rash. They disappear on pressure.

Typhus Fever.—The eruption appears on the third to the seventh day of fever, in the form of round or oval, irregular, pink, erythematous macules on the neck, chest, abdomen, and extremities, which disappear on pressure.

Syphilis.—The secondary skin eruptions of syphilis appear, classically, eight weeks after the chancre, although "this statement must be interpreted with numerous reservations," as Stokes says. Constitutional symptoms of generalized invasion may be continuous with the chancre.

With the rash there is malaise, headache, alopecia and sore throat, with mucous patches in the mouth and vagina.

The rash is macular in over 40 per cent of cases, maculopapular in 20 per cent, follicular (around hair follicles) in 8 per cent, papular in 4 per cent, papulopustular in 1 per cent, and mixed in the rest.

The tendency of distribution is as follows: the macular on the flanks and abdomen, shoulders, back and upper arms; papular, the same, with predilection for face, palms, and soles; pustular, face and scalp; follicular, back, scalp, and extensor surfaces.

In *configuration* secondary syphilis has a marked tendency to grouping and ring-shaped grouping. *Induration* is a marked feature and helps to distinguish syphilis from many other skin eruptions such as pityriasis rosea, psoriasis, ring-worm, erythema multiforme, and urticaria. *Indolence* is another characteristic: the eruptions do not spring suddenly into being, but emerge very gradually, persist a few weeks, and fade slowly.



Fig. 12.—Sulfanilamide rash.

5. Exfoliations of the Skin.—

Drugs causing exfoliative dermatitis are arsenic (especially common in anti-syphilitic medication with the arsphenamines), gold, the sulfonamides, sodium thiosulfate, and potassium sulfoeyanate.

Pellagra.—Pellagrous dermatitis is caused by the action of light and therefore occurs on exposed surfaces. The hands and face, then, are likely to suffer most. The effect of light in connection with the deficiency disease is in some way related to the excretion of porphyrin in the urine and feces. The der-

matitis is at first an erythema accompanied by burning and itching and thickening of the skin. After persisting for several weeks or months, there is a branny desquamation. The affected skin is likely to turn brownish.

6. Urticarial wheals occur probably exclusively, as allergic phenomena—to serum foreign protein, food to which the individual is sensitized, drugs (antipyrine, aspirin, barbitol, insulin, luminal, morphine, phenacetin, salicylates, tryparsamide), perfumes, clothes, and to unidentified, probably intestine-absorbed, toxins.

Angioneurotic edema was first described by Heinrich Quinke, of Kiel (Monatsh. f. prakt. Dermat. 1: 129-133, 1882), as "Acute localized edema of the skin:

"The disease manifests itself in the appearance of edematous swellings of the skin and subcutaneous tissue in localized spots from 2 to 10 and even more centimeters in diameter. These swellings are most commonly on the buttocks and the face, here particularly on the lips and eyelids. . . . The mucous membranes may at the same time be affected by these swellings, for example, the uvula, the entrance to the pharynx and larynx, indeed to such a degree that a severe asphyxia appears. Also in the gastric and intestinal mucosa producing symptoms. In one case also repeated effusions into the joints. These swellings appear suddenly, usually in several places at the same time. They reach in one to a few hours their maximum and then vanish very quickly after they have lasted several hours or a day. While the eruptions disappear in one place, new eruptions may appear at very distant spots, so that the disease in this manner may last several days or even weeks. . . . When an individual has once had this acute edema it very often comes back in new attacks, usually localized in the same spots. . . . Occasionally a cooling off of the skin, catching cold, or a physical strain could be demonstrated as active causative factors. The disease appears more often in men than in women. The individuals attacked are otherwise healthy, some of them are rather irritable. . . . There is a similarity to erythema multiforme and also to urticaria. . . . It must be considered as an angioneurosis."

Little has been added to this classic and clear description, except to point out the distinction between the hereditary and acquired forms (Dunlap and Lemon: Hereditary Form of Angioneurotic Edema, Am. J. M. Sc. 177: 259, 1929). The hereditary form is quite likely to terminate fatally with edema of the glottis; 21.1 per cent of 170 patients reported by Bullock died in this way. Quinke evidently described the acquired form.

7. Herpetic eruptions, whether the simple herpes of the lip or herpes zoster, are probably due to a filtrable virus. The pain and association with nerve tracts, as well as their appearance, serve to make them familiar to all internists.

8. Keratoses.—So far as they are due to generalized diseases the keratoses are largely manifestations of vitamin deficiency. In vitamin A deficiency there are keratotic papules of various sizes distributed over the extremities and shoulders. They form in the hair and sebaceous gland follicles as keratotic plugs. Varying grades of severity have been described, the worst being toad skin, or phrynoderma, in which large warty excrescences occur.

Another form of vitamin A deficiency manifested in the skin is a dryness and roughness upon which localized eruptions later are imposed, described by Frazier and Hu who observed it in China. The lesions appear suddenly on a localized area—thighs, forearms—then extends to shoulders, abdomen, back, and buttocks. Hands and feet are not involved. There is absence of sweating. The eruption is distinguished by hyperkeratosis, especially of the hair follicles, which are filled with a keratotic plug. These plugs project from the hair follicles as horny spines.

The skin lesions of vitamin A deficiency may long precede the hyperkeratinization of the conjunctival and corneal epithelium, resulting in xerophthalmia and keratomalacia.

Pellagra produces a dermatitis which is essentially keratotic in nature. It affects the neck (the pellagra collar), the hands, feet and lower extremities, and the face. The face that the exposed parts of the body are exclusively affected, indicates the relation to light sensitivity. This possibly has some relation to porphyrin metabolism.

On the face the eruption produces a very characteristic appearance of the nose. There is a dull erythema with scaling so that it looks as if a dull red nose had been covered with powder. On the neck, hands, and feet the eruption is at first brightly erythematous and ends in a sharp line of demarcation. Later there is desquamation.

9. Generalized Vesicular or Vesiculopustular Eruptions.—

DRUGS.—Vesicular eruptions are not common from ingested drugs, but frequent from contact.

DERMATITIS VENENATA.—Contact with plants, such as primrose, poison oak, poison ivy, poison sumac, gives vesicular eruptions.

INFECTIONS.

Smallpox.—The prodromes begin abruptly with a high temperature, headache, and joint and muscle aching. Backache may be severe. There is usually no characteristic eruption for several days, although there may be a generalized erythema. The axillae again should be inspected for the erythema. The typical poeks appear first on the face, neck, upper chest or on hands and forearms. The distribution is centrifugal (away from the center) on the exposed surfaces, a point in which it differs from chicken pox. The eruption at first consists of macules or maculopapules. These change to vesicles twenty-four to forty-eight hours after their first appearance. It is firm and shotty to the touch, and soon becomes umbilicated; by the sixth day it is usually pustular.

Chicken Pox.—Prodromes are short and mild. There is often an erythematous prodromal rash. Backache may be even more severe than in smallpox. The eruption at first takes the form of macules, but rapidly becomes papules and then vesicles. The distribution tends to be centripetal (in the center) on the chest and abdomen. The lesions may vary greatly in size and form, hardly any two being of the same diameter or shape, an important differential point from smallpox where the tendency is for uniformity of size. Chicken poeks are usually discrete.

In a group of 625 cases reported by Top (*Handbook of Communicable Diseases*, The C. V. Mosby Co., 1941), chicken pox was correctly diagnosed in 90.9 per cent, and smallpox was mistaken for chicken pox in 1.6 per cent. Impetigo, scabies, and pustular dermatitis were called chicken pox and vice versa.

In adults severe and fatal forms of the disease due to pneumonia and encephalitis may occur as reported by Waring, Neuburger, and Geever (*Arch. Int. Med.* 69: 384, March, 1942).

Herpes zoster constitutes a peculiar form of complication, and it has been authoritatively suggested that it is caused by the same virus.

10. Color Changes of the Skin.

A. JAUNDICE.—See p. 122.

B. CAROTINEMIA, XANTHOMATOSIS.—

Carotinemia is a yellowish discoloration of the skin due to absorption in abnormal amounts of the lipochrome pigments, carotin and xanthophyll. These pigments are found in carrots, most green vegetables, squash, skin of oranges, milk, and egg yolk. *Xanthosis diabetica* is a form of carotinemia in which the discoloration is deposited in localized plaques. In the mild, and these are by far the most frequent, cases of carotinemia the discoloration occurs only on the nasolabial folds, on the palms and soles and on the hyperkeratotic areas of the body, and around the sebaceous glands. Occasionally the entire skin is universally pigmented. The sclera, however, is always clear, an important point in differentiating a puzzling case from jaundice. Nor is there ever any pruritus with carotinemia.

The blood serum in carotinemia is yellow or orange. To test for carotin take 3 c.c. of blood serum, add 3 c.c. of 95 per cent alcohol and 3 c.c. of petroleum ether and centrifuge the mixture. If carotin is present, it passes into the upper layer of the petroleum ether, giving it a yellow color. Bile pigments remain in the alcohol.

Most cases of carotinemia occur in diabetics. This is partly due to their vegetable dietary, but Rolli and his colleagues (*Effects of Carotene and Vitamin A on Patients With Diabetes*, J. A. M. A. 106: 1975, 1936) advance evidence to show that in diabetes the liver is unable to convert carotene to vitamin A in normal amounts.

Myxedema is another disease in which carotinemia is frequently reported, and it may be that the "muddy" or "sallow" complexion as classically described has this chemical basis (Escamilla: *Carotinemia in Myxedema*, J. Clin. Endocrinol. 2: No. 1, Jan., 1942, and Escamilla et al.: *Ann. Int. Med.* 9: No. 3, Sept., 1935).

One patient of mine was deeply discolored but had no metabolic disease of any kind. He was a recluse, dietary faddist who had drunk a quart of carrot juice a day for three years.

The diagnosis of carotinemia is of importance in that it may be mistaken for jaundice. Boeck and Yater (*Xanthemia and Xanthosis: A Clinical Study*, J. Lab. & Clin. Med. 14: 1129, 1929) report six of twelve nondiabetic patients who had carotinemia and were investigated under the diagnosis of cholecystitis.

Xanthomatosis (Hand-Schüller-Christian's disease) is a disorder of lipid metabolism (somewhat akin to Gaucher's and to Niemann-Pick's disease) occurring almost exclusively in children. The triad of fundamental signs is: (1) defects in the membranous bones, (2) exophthalmos, and (3) diabetes insipidus. The skin becomes yellowish-brown or small xanthomas (papular lesions with a red border and yellow center) may be scattered over the face and trunk.

C. CYANOSIS. See p. 135.

D. OTHER DISCOLORATIONS OF THE SKIN.

Methemoglobinemia and Sulfhemoglobinemia.—The clinical picture is that of a person with a "muddy" complexion (it seldom is extreme enough to be called cyanosis and indeed the color is not exactly cyanotic) who thinks this complexion is due to constipation and who often has or anticipates a headache, also ascribed to constipation, and who regularly takes a morning dose of bromoseltzer or headache powder to correct these real or anticipated ills. I have known patients with such a discoloration who made half a dozen or more trips from the office to the drugstore for a glass of bromoseltzer in the course of the morning.

The discoloration of the skin in such cases was called methemoglobinemia until Snapper (*Deutsche med. Wchnschr.* 51: 1925) clarified the situation by showing that the aniline derivative, acetophenetidin, when taken by mouth in large amounts, produced a union of sulfur with hemoglobin. He postulated that the acetophenetidin "sensitized" hemoglobin so that it would combine with hydrogen sulfide normally absorbed from the intestine. Methemoglobinemia can occur from the ingestion of aniline derivatives, but it is very unstable in the blood stream and rapidly disappears: it occurs only when very large doses are absorbed over a short time. Most of the cases of methemoglobinemia reported are really sulfhemoglobinemia. The discoloration due to sulfhemoglobinemia disappears very slowly after withdrawal of the drug, sometimes not for weeks or months. This is a point in differential diagnosis because *methemoglobinemia disappears very rapidly after withdrawal. The tests for these pigments in the blood are spectroscopic.* (See Harrop and Waterfield: *Sulfhemoglobinemia*, J. A. M. A. 95, Aug. 30, 1930.) Henderson and Haggard (*Noxious Gases*, Am. Chem. Soc. Monographic Series, 1927) state that hydrogen sulfide does not combine with oxyhemoglobin, but only with methemoglobin. Therefore, the term sulfmethemoglobin is really preferable to sulfhemoglobin.

Enterogenous cyanosis is due to the formation of sulfmethemoglobin in the intestine, not involving the use of any of the drugs mentioned above. The first case described (Stooke's) was that of a man, aged 38 years, with a severe enteritis. Van den Bergh has described a case in a boy with congenital anal stricture.

Shoe dye poisoning presents a bright cyanosis and is not at all uncommon. Brown or white shoes dyed black with a dye containing nitrobenzene or aniline

are the source of the poisoning. If the shoes are worn too soon after the dye has been applied, and the feet warm up and sweat, aniline or nitrobenzene is absorbed directly into the blood. Symptoms besides the discoloration are vertigo, nausea, vomiting, headache, and weakness. The blood is a dark chocolate color. A case has been reported in an infant when the diapers were marked with an aniline ink by a laundry. Nitrobenzene and aniline poisoning are well known in industry. In spite of precautions instituted by health boards against shoe dyes of the character described, the condition continues to recur and may be very puzzling. (See Muehlberger: Shoe Dye Poisoning, J. A. M. A. 84: June 27, 1925.)

Argyria.—The deposit of silver in the skin produces a bluish metallic discoloration. During the mid-decades of the nineteenth century silver salts were given orally for gastrointestinal and nervous disorders (especially epilepsy), but the frequent production of argyria brought this therapy into disfavor. Of recent years reports have been made of the production of argyria from installation of silver preparations (usually colloidal with a soluble protein base) in the nose. The condition, once established, is permanent. (See Berkely: J. A. M. A. 102: No. 3, Jan. 20, 1934. Also very interesting article by Levine and Smith: New England J. Med. 226: 682, April 23, 1942.)

Bismuth discoloration of the skin is so rare that only one proved case is extensively described in the literature (Lueth, Sutton, McMullen and Muehlberger: Arch. Int. Med. 57: No. 6, June, 1936). The coloration resembles argyria. The subject of the description cited was a male, who for eighteen years had taken 20 grams of bismuth subnitrate a day on account of diarrhea and digestive disturbances. Ten years after beginning this he suddenly, in three days, turned a bluish-black metallic color which has remained the same ever since. The conjunctiva were somber gray. He was edentulous and all the buccal and pharyngeal membranes were a deep indigo black. Histologic examination of a biopsied skin specimen showed pigmented granules in the subdermal layers, and chemical examination extracted bismuth.

E. PIGMENTATION OF THE SKIN.—The pigmentation of Addison's disease is described on p. 232.

Hemochromatosis, or bronze diabetes, is a disorder of iron metabolism characterized by a bronze or bluish-black pigmentation of the skin, and by the occurrence of diabetes, cirrhosis of the liver and of the pancreas, and often of the endocrine glands. The mechanism is obscure. The skin pigmentation and the cirrhoses are due to the deposit, especially of hemosiderin. There is a disturbance of the intracellular iron metabolism, although the hemoglobin seems to escape entirely. There is a marked retention of iron in the body. It occurs in middle age, men predominating 30 to 1. Diabetes usually precedes the pigmentation by several years. The liver is palpable and tender. The spleen is usually palpable. There is a secondary anemia. Genital hypoplasia is frequent. The pigmentation is generalized but more on the exposed parts in most cases. In the second largest group, there is intense bronzing on the

genitals. Occasionally the mucous membranes are affected, the hard palate and gums. The discoloration is variable and usually improves as the diabetes improves. (See Althausen and Kerr: *Endocrinology* 17: 621, 1933, and Brett and Wilder: *Arch Path.* 26: 262, 1938.)

Ochronosis is a disorder of pigment metabolism with the occurrence of a bluish discoloration in the cartilages of the ears, the sclera, often but not always, the lips and fingernails, and sometimes, the skin, and in extreme cases the tendons can be seen through the skin to be greenish or bluish. At autopsy the cartilage of larynx, the trachea, bronchi, rib cartilages, and intervertebral discs are also pigmented. The pigment is probably a form of melanin. The origin may be the use of phenol locally over a prolonged period. Other cases occur in association with alkaptonuria. Osteo-arthropathy is a regular accompaniment. (See Oppenheimer and Kline: *Arch. Int. Med.* 29: 732, 1922.)

F. PALLOR is a reliable indication of considerable bodily disturbance. When actual—that is, when not simply a naturally pale complexion—it always means something. The causes are primarily circulatory, hematogenous, infectious, and cachectic.

Coming on acutely, it is most often circulatory in origin—sudden withdrawal of blood from the skin capillaries. Emotional shock, fainting, syncope, trauma, surgical shock, anginal attacks, acute heart failure with or without pulmonary edema, onset of chills, bronchial asthma or convulsion, intoxication from alcohol or other drugs, full dosage of adrenalin, all produce pallor by much the same mechanism. The hematogenous cause of acute pallor is hemorrhage, external or internal, of sufficient amount to reduce suddenly the volume of the circulating blood.

Pallor of more or less gradual onset: Circulatory causes are cardiac infarction, bundle branch block, auriculoventricular block, aortic regurgitation, aortitis, congestive heart failure, arteriosclerosis, hypotension and hypertension in the malignant form or terminal stages.

Hematogenous causes are anemia of any kind—menorrhagia, metrorrhagia, hemolytic agents such as lead, mercury, benzol, radium and x-ray, chronic bleeding from peptic ulcer, hemolytic infections such as malaria, streptococcus hemolyticus, dibothriocephalus, etc.

Lipoid nephrosis should perhaps be separately mentioned. It produces a marked pallor which may be said to be partially hematogenous (the anemia) and partially circulatory (the edema) in origin.

Some infections are marked by pallor without there being any very marked or obvious anemia. Chronic pulmonary tuberculosis, syphilis, chronic gonorrhea and subacute bacterial endocarditis, focal infections, emphysema, and bronchiectasis are among these.

Cachexia is an indefinite term which, however, certainly depends mainly on pallor (accompanied, of course, by wasting, weakness, slow movements, malnutrition). Carcinoma or any malignant tumor, Hodgkin's disease, leucemia, nephritis, myxedema, periarteritis nodosa, and many chronic states are examples.

G. ANEMIC CHANGES.—

Chlorosis was called the green sickness, a somewhat poetic hyperbole. The patients are not exactly green, but a sort of dirty white. The Dutch painters of the "Lovesick Maiden" series got the color exactly. There is an iron deficiency in the blood and this seen through more or less well-fatted skin gives the color. At least, I know of no other explanation.

Pernicious anemia gave most often a characteristic light lemon-yellow color to the skin by which it was possible for the "pathologist in the street" to make the diagnosis. The middle-aged patient with pernicious anemia commonly preserved his subcutaneous fat intact, and the explanation of the color was usually that the skin, made transparent by the "thinness" of the blood, allowed the color of the fat to shine through. Haden, however (*Principles of Hematology*, Lea & Febiger, 1939, p. 271), states: "As a result of this excessive death of cells in the marrow, an increased amount of bile pigment is formed. This accumulates in the blood plasma to give the characteristic high icterus index and the typical yellow color to the skin or even clinical jaundice." Some cases showed merely pallor, some were bronzed.

Secondary anemia usually presents as pallor.

11. Quality of the Skin.—Whether the skin be smooth or rough, thick or thin, or atrophied indicates in a general way the state of health, the state of the nutrition, vitamin intake, sexuality and age, but specific deductions for diagnosis to be made from such observations are few. Many of these qualities are natural to the individual, congenital and not acquired. An example of acquired smoothness is hyperthyroidism. Pellagra and other vitamin deficiencies roughen the skin. Female skin is smoother than male, and any endocrine disturbance which throws the balance of sexuality one way or the other will influence this quality. The skin of old age is atrophied.

EDEMA OF THE SUBCUTANEOUS TISSUES.—

Edema fluid is plasmalike and accumulates in the subcutaneous, especially areolar, tissues and serous cavities when: *first*, the hydrostatic pressure in the capillary bed is increased (circulatory); *second*, there is a change in the plasma especially affecting osmotic pressure (renal, hepatic, and nutritional); *third*, capillary permeability is increased—mostly localized rather than generalized (inflammatory around local injuries, urticaria, angioneurotic edema); *fourth*, there is lymphatic obstruction (filariasis, elephantiasis, Milroy's disease[?]); *fifth*, the blood stream flow is slowed.

Physiologic explanations of the mechanism of these various forms of edema are by no means entirely satisfying. Common sense tells us that circulatory edema is due to increased venous pressure and that nephritic edema is due to chemical changes in the blood with imbalance of osmotic pressure, but when physiologic experiments to verify these assumptions are carried out, the results are far from exact or clear.

In congestive heart failure there is a rise in venous pressure, and also decreased muscular activity. This increases the effective filtration pressure in the capillaries. In addition, there is found increased permeability of the

capillaries to water and colloids and in some cases a fall in effective colloid osmotic pressure of the plasma because some protein passes into the tissue spaces. All these factors enter into the production of the edema, which is thus seen to be a complicated process. (See Smirk: *Edema in Congestive Heart Failure*, Clin. Sc. 2: 317, 1936.)

Nephritic edema with the kidney described as the arteriosclerotic, or the chronic glomerulonephritis with hypertension is usually, in my experience, due to the heart failure rather than to chemical and physiochemical blood changes resulting from the nephritis.

Lipoid nephrosis presents the purest picture of edema due to kidney failure. One factor is hypoproteinemia and another is a disturbance in electrolytic and water balance between blood and tissues. There is a great reduction of serum albumin, resulting in a disturbance of the serum albumin-globulin ratio. Nutritional deficiencies also result in loss of serum protein and this may account for the edema present in these states. The composition of tissue fluid is kept extraordinarily constant in health by variations in kidney function. The chief base is sodium which makes up about 140 of the total of 150 milliequivalents per liter. Anything which increases the total amount of sodium in the body tends to edema, and a depletion of sodium to dehydration, but the normal kidney adjusts to these changes with great sensitiveness, excreting excess sodium in the one case and withholding sodium in the other. When the mechanism breaks down, however, edema usually results.

Technical methods for the identification of edema besides a routine history, physical examination, and urinalysis include determination of the plasma protein, specific gravity of the plasma and determination of venous pressure. Determination of the specific gravity of plasma can be made simply by any of several techniques which depend on the speed of fall of a drop of plasma through fluid of known density. (See Barbour and Hamilton: *The Falling Drop Method for Determining Specific Gravity*, J. Biol. Chem. 69: 625, 1926. A 10 c. mm. drop of blood is turned as it falls over a distance of 30 cm. through a mixture of xylene and bromobenzene in a tube of exactly 7.50 mm. bore. Its falling time is compared with that of a 10 c. mm. drop of standard K_2SO_4 solution of known density. The details are too complicated for repetition here. (See Barbour and Hamilton's original article.)

The direct measurement of venous pressure is done by inserting an 18-gauge needle in an antecubital vein and connecting it with a manometer filled with saline, and relating the height of the saline to the estimated level of the right auricle. It is normally 10 cm. (Lyons: *Measurement of Venous Pressure by the Direct Method*, Am. Heart J. 16: 675, 1938. See also, Ellis: *Causes and Treatment of Edema*, New England J. Med. 224: No. 25, June 19, 1941—good bibliography.)

III. THE ENDOCRINE SYSTEM

Disturbances of the endocrine glands in most instances affect the body as a whole, so it is convenient for the examiner to record his findings in the endocrine system under this heading in the clinical record.

RELATIVE FREQUENCY OF ENDOCRINE DISORDERS

Reported in Grollman's *Essentials of Endocrinology*, from statistics furnished by the Johns Hopkins Hospital (1,599 cases of endocrine disease among 49,466 patients):

Diabetes	897	Thyroiditis	9
Hyperthyroidism	372	Cretinism	6
Hypothyroidism	114	Hyperinsulinism	5
Adrenal insufficiency	61	Pineal tumor	5
Adenoma of the hypophysis	39	Adiposogenital dystrophy	4
Tetany	32	Granulosa cell of ovary	4
Pituitary insufficiency	18	Precocious puberty, male	4
Hyperparathyroidism	15	Precocious puberty, female	3
Hypogonadism, male	12	Pituitary basophilism	2
Myxedema	12	Hypogonadism, female	1

ESPECIAL FEATURES OF EXAMINATION OF THE ENDOCRINE SYSTEM

Routine examination of a suspected endocrine patient should not be different in general form from that of any other patient. The endocrine patient is entitled to have heart disease, tuberculosis, syphilis, or cirrhosis of the liver as much as if he were not also "endocrine," and the physician must be satisfied whether or not any such conditions are in the background.

In addition to the routine history and physical examination, however, there are physical data which the physician must know about the suspected endocrine patient and the following brief routine is the minimum which should be followed in these cases:

1. Anthropometry—measurements of height, span, upper and lower body segment and weight.
2. Fat distribution or type of leanness.
3. Basal metabolism.
4. Blood sedimentation test.
5. X-ray bone studies at least of carpus and sella.
6. Chemical laboratory: Blood cholesterol. Forty-eight-hour creatine excretion test. Glucose tolerance test. Blood calcium.

Disease of the endocrine system manifests itself in some disturbance of one or more of the following:

1. Stature, body proportions, bone growth or bony abnormality. Teeth.
2. Weight—unusual obesity or leanness.
3. Anomalies of sex.—Heterologous secondary sex characteristics, hirsutism, gynecomastia, voice pitch, wide pelvis. Menstrual disorders.
4. Anomalies of intelligence—somnia, sluggishness. Nervousness, etc.
5. Eye—exophthalmos, cataract, anomalies of pigmentation.
6. Skin—pigmentation, sweat and sebaceous glands, keratinization, striae, etc.
7. Muscular disorders—tremor, tetany.
8. Disturbances of sugar, water, and salt metabolism.

1. Stature

The best indication of the state of skeletal growth is seen in the carpal and tarsal bones as they appear on the x-ray plate. The first center becomes visible in the wrist at the age of six months. Between the ages of one and two years, two small centers are present, and for each year following a new center is added, while the older centers gain in size and density. At the age of eight years all eight carpal centers can be seen, but they are undeveloped and do not replace the whole cartilaginous structure. At the age of ten to twelve years ossification of the carpal bones is complete. Another guide is the ossification of the epiphysis of the ulna at the wrist, which normally appears between the ages of four and seven years. (For details see Shelton: *J. A. M. A.* 96: No. 10, 759, March 7, 1931.)

Influence of hormones on ossification.—The thyroid has the most marked and constant effect on ossification proper. The normal development of ossification is apparently largely controlled by a regular and adequate secretion of the thyroid, checked perhaps by the gonad and pituitary secretion. To put it another way, if there is a marked increase or decrease of gonadal or pituitary secretion this is likely to throw the normal rate of ossification, which is under the control of the thyroid, off balance. That, at least, seems to me the best interpretation in the present state of our knowledge.

The bone age of the hypothyroid child is well below its actual age. At the age of six years there may be only two carpal centers of ossification. The carpal ossification is of unassailable value for diagnosis. The lack of ossification of the epiphyses is the cause of the shortness of the long bones.

Ossification studies are of primary importance to determine hypothyroidism in children. As Shelton (op. cit.) says: "Comparatively few hypothyroid children present the clinical evidence of cretinism or myxedema unless the condition is far advanced. As a consequence, many are considered normal until some outspoken evidence of the deficiency is presented in later life. It is equally certain that the onset of adolescence (gonadal function) has something to do with the epiphyseal closure. In America this occurs in the female between the ages of twelve and fourteen: and yet a girl who began menstruating at ten and one who has not menstruated at sixteen are frequently considered normal." So, to repeat, the only certain and constant standard which remains is the state of ossification.

Hypergonadism results in premature ossification of the epiphyseal cartilages and this soon terminates the skeletal growth, but before ossification is complete these children usually attain proportions equal to or beyond their age. However, they seldom attain adult proportions. Bone age, as shown in carpal x-rays, is premature—a three-year-old child may have the ossification of a child of eight or ten years. Hypergonadism of this type may be associated with pituitary or adrenal tumors.

The measurement of the influence of the pituitary growth hormone is determined not by ossification centers, as in the case of the thyroid, but in the state of closure of the epiphyseal junction in the long bones. Astwood (*J. Endocrinol.* 1: 49, June 19, 1939) in animal experiments found that after hy-

pophysectomy in 45-day-old rats, bone growth ceased seven days after operation. The epiphyses closed soon after hypophysectomy. Silberg (*Proc. Soc. Exper. Biol. & Med.* 32: 1423, June, 1935) showed that injections of anterior pituitary extract exerted a stimulating effect on the growth of cartilage and bone of growing guinea pigs. Histologic studies showed that the various layers of the cartilage cells become hypertrophied and hyperplastic and are subsequently quickly calcified and replaced by bone. These experimental studies are confirmed by such reports as that of Traub (*Arch. Dis. Childhood* 14: 203, Nov., 1939) who found lack of epiphyseal closure and even epiphyseal necrosis with consequent unrestrained growth of the long bones in pituitary giantism.

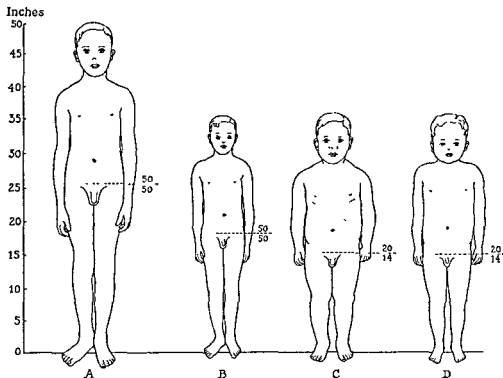


Fig. 13.—Diagram to show that the skeletal proportions of dwarfs with hypothyroidism correspond to the height age while those of other dwarfs belong to the chronologic age. A, normal boy—8 years old; B, dwarf (nontypothyroid)—8 years old; C, dwarf (hypothyroid)—8 years old; D is the same height and has the same symphysis line (upper to lower length proportions) as a two-year-old child. (See Wilkins and Fleischmann: *Hypothyroidism*, J. A. M. A. 116: 2461, 1941.)

Basic Growth Types.—The measurements of the body have a fixed normal relationship. In a normal adult the distance from the bottom of the feet to the symphysis pubis is the same as the distance from the symphysis to the vertex. The length of the span of the outstretched arms from finger tip to finger tip is the same as the height from vertex to sole.

These proportions are the result of an intimate balance between the secretions of the thyroid, the anterior pituitary, and the testes during childhood and prematurity. The thyroid secretion controls ossification centers as noted above and when its secretion is diminished, growth in general is retarded, but

particularly the long bones, so that if before the termination of skeletal growth the hypothyroidism exists, the legs and arms are proportionately shorter than the trunk.

The secretion of the anterior pituitary (probably the eosinophile cells alone) results in closure of the epiphyseal junction of the long bones. Should the sexual hormone of the gonads (stimulated by the gonadotropic hormone of the anterior pituitary) cause early maturity (which can be pretty definitely marked in the female by the onset of menstruation) the epiphyses will close early, resulting in much the same type of body conformation as the hypothyroid—short legs and arms and long trunk.

If the sexual hormone of the gonads is deficient or retarded in its action, the growth hormone of the anterior pituitary will have full play and the epiphyseal closures will be delayed, allowing growth of the long bones; the bodily proportions will therefore be those of eunuchoidism or pituitary gigantism, with the legs and arms proportionately very long and the trunk short.

The action of the anterior pituitary on growth is quite definite. If a young animal is hypophysectomized, it will immediately stop growing both in length of body and in weight. If such an animal be given the extract of the "growth-promoting hormone" of the anterior pituitary, normal growth will be resumed. If a normal animal be given regular doses of the growth-promoting hormone, it will show abnormal increase in growth beyond its litter mates. Evans (*Growth Hormone of the Anterior Lobe of the Pituitary Gland*, J. A. M. A. 117: No. 4, July 26, 1941) states most emphatically that this growth hormone is separate from the target (or tropic) organ hormones; that, in other words, it does not accomplish its action by influence on the thyroid, adrenal, testes, ovary, or thymus. The role of the thymus in bone growth is very debatable. The thymus has an epithelial origin (from the ventral diverticula of the third lateral pharyngeal projections) and may, for this reason, be theoretically assumed to be a gland of internal secretion. Early in postuterine life, however, a widespread lymphocytic infiltration into the parenchyma destroys most of the epithelial cells. The gland is large in childhood, begins an involution at about the age of four which is completed or hastened at puberty: thus it has been assumed, because these changes correspond to growth periods, that the thymus has some influence on growth. But late opinion more and more inclines to regard this as dubious. Extirpation of the gland does not lend itself readily to clinical interpretation because the extirpation itself is so hazardous and destructive, but, for what it is worth, it has been reported that the most striking deficiency observed in thymectomized animals has been a faulty skeletal development resembling the deformities which occur in rickets. Clinically the influence of the thymus on skeletal deformities or growth abnormalities may be disregarded.

A number of basic growth types have been described, but for practical purposes they can be reduced to four:

1. Normal basic growth type—span equals height, lower half equals upper half.

2. Stocky type—hypothyroid or hypergonad. Span shorter than height, lower half less than upper half. In the hypergonad stocky type sexual maturity is precocious. The females menstruate at ten or eleven years, sometimes as early as seven and the males have penile development, heavy body hair distribution, and voice changes at ten or eleven.

3. Eunuchoid types. The span is longer than the height, the lower half is longer than the upper half. X-ray plates will show that the epiphyses have not united with the shafts of the long bones. This is often seen beautifully in the hand, with the epiphyseal disks quiet distinct from the phalanges. This is the basic reason for the long, slender fingers of the pituitary type.

There is no fundamental difference between eunuchoidism and pituitary giantism so far as growth pattern is concerned. The eunuchoid individual has retarded sexual development, while the pituitary giant may be normal sexually. Both are tall, but the pituitary giant in the extreme examples goes on to acromegalic giantism with characteristic facial changes.



Fig. 14.—Cretinism.

The eunuchoid type may be lean or fat. The obese types merge into Fröhlich's dystrophia adiposogenitalis.

4. Infantilism preserves the normal basic growth pattern of equal span and height, lower half and upper half, but cannot be called normal because all the measurements are small. There is dwarfism and retarded sexual development of both primary and secondary sexual characters. (See Werner: *Basic Growth Types*, *J. Iowa S. M. Soc.* 31: 181, May, 1941.)

Cretinism should be suspected in the first weeks of life from the general bodily appearance, prominent abdomen and persistent umbilical hernia. As time goes on, skeletal growth is delayed, but by the time that is ascertained it is almost too late for therapy.

Hypothyroidism in children is a clinical group which takes up a large part of the endocrinologist's time. The bodily changes in frank cretinism and juvenile myxedema are so marked as concerns skeletal growth, mental development, and changes in the skin, hair, etc., that it is not unnatural that a number of

minor variations should be ascribed to minor degrees of hypothyroidism. The literature resulting from these speculations is often lacking in critical standards. Wilkins and Fleischmann (*The Diagnosis of Hypothyroidism in Childhood*, J. A. M. A. 116: No. 22, May 31, 1941) have endeavored to analyze a group of cases with more critical exclusiveness than is usually displayed. They list the following signs as possible indications of hypothyroidism in children:

Skeleton:

Stunted height.

Skeletal proportions infantile—upper longer than lower segment—short extremities.

Naso-orbital development—infantile.

Osseous development (carpal bones)—retarded.

Dental development—retarded and defective.

Epiphyseal dysgenesis—frequently present.

Other structures:

Brain development—retarded.

Skin—variable.

Hair—variable.

Subcutaneous tissues—variable.

Functional changes:

Physical and mental torpor.

Peripheral circulation poor—skin pale, grayish, cool.

Pulse rate, pulse pressure—decreased.

Sweating—variable.

Constipation.

Basal metabolism—25-40 minus.

Serum cholesterol—high.

Hypothyroidism is undoubtedly one of the commonest causes of dwarfism. Wilkins and Fleischmann found that in a series of 64 dwarfs studied by them, 16 were definitely due to hypothyroidism and all but one responded to thyroid therapy.

Skeletal proportions of the hypothyroid dwarf show a relatively long trunk and short extremities. Normally the ratio of the upper segment at birth is 1.7 to 1.0. The lower segment normally grows faster than the upper. At five years the ratio is 1.2 to 1.0, and at ten or eleven years 1 to 1. Hypothyroid dwarfs maintain the infantile proportions into adult life, while other dwarfs (except the chondrodystrophic) have skeletal proportions approximately normal for their chronological age.

The *naso-orbital* configuration of the hypothyroid dwarf gives it a characteristic expression. The bridge of the nose is wide and flat, making the eyes seem wide apart. The nose is short and undeveloped.

Retardation of osseous development is shown best in the carpus. Such retardation is not confined to hypothyroid dwarfs alone: 60 per cent of all dwarfs studied by Wilkins and Fleischmann had a delay of two to six years in appearance of centers of ossification.

Epiphyseal dysgenesis is, according to Wilkins and Fleischmann, the most specific of all anatomic changes of hypothyroidism. It consists of "a disorder of the cartilages of the epiphysis and round bones leading to irregularities in their subsequent ossification."

"Normally, ossification begins from a single small focus in the center of the cartilage and extends peripherally in an orderly manner. If thyroid deficiency exists during the period in which ossification normally occurs, the appearance of the deposition of calcium is considerably delayed. When calcification finally occurs, it appears as multiple, small, irregular foci scattered over a considerable area of the cartilage. These grow larger and coalesce to form a single irregular center. According to the stage of the process, the roentgenogram may show multiple small centers of ossification or a single center which may appear either stippled, porous, fluffy, or fragmented. In the head of the femur the condition often cannot be differentiated in the roentgenogram from Perthes' disease. The two conditions, however, are entirely unlike in their pathogenesis. Perthes' disease is a destructive process involving an epiphysis which has previously been normally formed; in hypothyroidism there is an abnormality in the development of the cartilage and its conversion into bone. Although hypothyroid epiphyseal dysgenesis is observed most frequently and is most spectacular in the heads of the femurs and the navicular of the tarsus, it involves all the endochondral centers in which ossification normally occurs during the period in which the deficiency exists. It can be found if roentgenograms are taken frequently enough to show the earliest appearance of calcification."

The development of the teeth is always retarded in hypothyroid dwarfs. The teeth which do erupt are especially liable to caries.

• Basal metabolism is naturally difficult to obtain in children on account of lack of cooperation and can be checked by the serum cholesterol, which is always high in hypothyroidism—250 to 600 mg. compared with a normal range of 100 to 300 mg. Any concentration above 300 mg. is suggestive of hypothyroidism, provided other causes of hypercholesteremia, such as diabetes, nephrosis, and hepatic disease, can be ruled out. The blood cholesterol level falls under thyroid treatment. Creatine excretion is low in hypothyroid children. Normal children, however, show considerable variation in creatine excretion, from 0.5 to 8 mg. per kilogram of body weight. (See Wilkins, Fleischmann and Block: Studies on Hypothyroidism in Children: the Basal Metabolic Rate, Serum Cholesterol, and Urinary Creatine Before Treatment, J. Clin. Endocrinol. 1: 3, Jan., 1941.)

Pituitary insufficiency in childhood does not lead to any retarded or disproportionate growth of bones, but the bones of the young hypopituitary subject are, like its skin and hair, delicate and slender, the finger bones very tapering.

Hyperpituitarism from overgrowth (tumor) and/or oversecretion of the eosinophile cells of the anterior lobe result in very marked bony changes. If this occurs before skeletal growth is completed, it results in pituitary giantism: the length of the upper part of the body is less than the lower and the span is greater than the height. If pituitary hyperfunction occurs after skeletal growth is complete, the condition of acromegaly develops with overgrowth of

the bones, particularly of the cranium and supraorbital region, the jaw, and the hands and feet. Acromegalic features may superimpose themselves on pituitary giantism.

Acromegaly is an overgrowth of certain parts of the bony skeleton, coming on in adult life, and due to adenoma or hypersecretion of the eosinophilic cells of the anterior pituitary.

Marie noted in his original description of acromegaly: headache, pain in the back and arms, thirst intense. "The whole feet are large, including the toes. The chest shows nothing peculiar, *beyond a marked posterior curve in the dorsal region*. This, though not angular, is distinctly marked. The hands are very large though of regular form. The tongue is enlarged. The face presents the appearance of a lengthened ellipse."



Fig. 15.—Acromegaly. Note position in which head is held, due to marked spinal involvement with kyphosis and scoliosis.

In all cases of acromegaly coming to autopsy or operation there was an adenoma of the anterior pituitary cells. Forty per cent of all giants are acromegalic. Twenty per cent of acromegalics are over 6 feet tall when the disease begins. Pathologically there is a bony overgrowth or tufting at the ends of the fingers and toes (acroextremities, megaly—enlargement). The bones of the jaw and face, particularly the supra-orbital prominences, show overgrowth. At postmortem all the internal organs are enlarged—universal splanchnomegaly. The disease occurs more frequently in women and often follows pregnancy. The age of onset is usually from 20 to 30.

The course of the disease is chronic and slow. There are many remissions and exacerbations. It is usually self-limiting and when the growth breaks out

of the sella most of the disagreeable symptoms disappear. In Mark's remarkable self-record case the disease began at about the age of thirty and he lived to be seventy-one. He describes his *black week*, during which he confined himself indoors and suffered feelings as if his skull were about to split—evidently the time the tumor broke from the sella. After that week his headaches, faceaches, and crises disappeared. The tumor in self-limiting cases becomes cystic.

The diagnosis of acromegaly will depend upon:

1. Gradually increasing size of hands and feet, necessitating new larger sizes of gloves and shoes.
2. Enlargement of the jaw, with malocclusion and requiring dentistry and new plates.
3. Enlargement of the face (notably the nose and lips), with the development of the characteristic *acromegalic facies*.
4. Development of dorsal kyphosis.
5. Headaches, faceaches, and mental crises due to intracranial pressure.
6. Local pressure signs of chiasmal, hypothalamic, or temporal lobe compression.
7. The tongue is enlarged, the skin hypertrophies and wrinkles, and becomes ridged like a bulldog's. Perspiration is profuse and has a peculiar acrid odor, even noticeable by the patient. Hypertrichosis is usual.
8. The basal metabolism shows an increase. There is frequently glycosuria, resistant to insulin. There is polyuria and hunger.
9. Menses cease in the female, and libido and potentia after a preliminary period of activity, are diminished in the male.
10. The x-ray film shows the characteristic changes in the terminal phalanges, face, and sella.

The changes of acromegaly as well as the changes that occur in general bodily structure in myxedema may come on so insidiously that neither the patient himself nor the immediate family notices them. This is particularly true of myxedema and is undoubtedly largely due to the mental sluggishness that is part of the disease. In acromegaly the mentality remains alert. But even so the bodily changes may occur without the victim being aware that there is any definite disease process at work. In this connection every clinician should read the account of Dr. Leonard Mark—*Acromegaly—A Personal Experience*. The author was on the staff of St. Bartholomew's Hospital, London, and fully cognizant of reported cases of acromegaly. He recalls that a colleague sent him a reprint of a case report which he read with not the faintest indication of any application to his own person. He gradually developed the large hands and feet; the prognathism, which required constant changes of dental plates in order to accomplish occlusion, all the most typical facial characteristics of acromegaly; eye signs, headache, faceache, etc. This went on for years when it suddenly occurred to him that he was suffering from acromegaly. It came in a flash as he was walking in the street. He went home and read the account in Bealby's Pathology, which confirmed him. The next day he consulted Sir Archibald Garrod, who said, calmly, "I have known that

for thirteen years." Garrod said that he had no idea Mark was unaware of his own condition, and refrained from mentioning it, because he thought Mark might be sensitive about it.

Bone Formation and Destruction.—Bone is made up of organic tissue and 15 to 18 per cent of calcium, which occurs in the form of two salts, calcium carbonate and tricalcium phosphate. During periods of ossification the cartilage becomes impregnated with these calcium salts; then the cells of the deeper layers of the membrane covering the cartilage—perichondrium—give off long processes to form a meshwork of interlacing fibers. These cells are the *osteoblasts* and are active in organizing the calcium impregnated cartilage into bony tissue. Other cells, the *osteoclasts*, absorb calcium and during the period of growth their action is constructive in determining the architecture of the bony structure. During adult life these processes of building up and breaking down are constantly going on and in health are kept in balance. Pathologic disturbance of this balance occurs in rickets, osteomalacia, osteoporosis, and osteitis fibrosa (and possibly acromegaly and chondrodystrophy could be so classified although in neither is disturbance of the balance of bone formation and destruction the primary process). During the active period of the development of these diseases the excretion of calcium and phosphorus is abnormal and the blood serum will show a disturbed percentage of calcium, phosphorus, and phosphatases.

In rickets and osteomalacia (which is chemically the same as rickets) the inorganic phosphorus of the blood is lower than normal, the serum calcium is normal unless the case is complicated by tetany, and the plasma phosphatase is greatly elevated. There is an increase in activity of the osteoblasts because of increased stresses and strains, a decrease of intake of calcium and phosphorus or at least difficulty in absorbing it from the gastrointestinal tract, and while there is an increased deposition of osteoid due to the activity of the osteoblasts it is inadequately calcified.

In osteoporosis there is a decrease in the mass of bone, due to hypoplasia of the osteoblasts, somewhat increased excretion of calcium and phosphorus, and normal serum values for calcium, phosphorus and phosphatase.

In osteitis fibrosa (due to hyperparathyroidism) there is increase in the activity of the osteoclasts, increased calcium and phosphorus in the urine, increased resorption of calcium and phosphorus, decreased mass of bone, increased activity of osteoblasts, because of stress and strain; the serum calcium may be plus or minus, the serum phosphorus minus, and the phosphatase increased.

Postmenstrual osteoporosis, a decalcification of bone in women following the menopause. There is a predilection for the bones of the spine and pelvis. The long bones are involved only in the severest instances. The skull is never involved. The common clinical forms are: (1) crushed vertebrae and, (2) "fish spine," in which the intervertebral disks expand into vertebrae, converting them into biconcave disks, and (3) herniation of the intervertebral disks.

The clinical story keeps repeating itself: A woman about ten years after the menopause receives a minor jolt (by going over a hump in an auto-

mobile, for instance); she experiences a pain in the back; finally she has a roentgen examination which reveals the condition, i.e., a fractured vertebra. There is increased excretion of calcium in the urine and many patients have urinary calculi.

In Albright, Smith and Richardson's series of cases (J. A. M. A. 116: 2465, May 31, 1941), 40 were women and 2 were men. Patients over sixty-five years of age were excluded because of the possibility of senescence as a factor. That the condition is not merely a question of age is disposed of by the examples of 10 women in whom osteoporosis occurred after artificial menopause, one forty-nine and one forty-two years old.

The bony changes of hyperparathyroidism, "the only known clinical manifestation of oversecretion of the parathyroid hormone" (Hoskins), make up that remarkable disease, *generalized osteitis fibrosa cystica* (von Recklinghausen's disease). It consists of gradual rarefaction and softening of the bones with the development of multiple areas of cystic degeneration. In the terminal stage the patient is a bedridden mass of skeletal deformities due to multiple spontaneous fractures. Adenoma of the parathyroid cells is the cause in most cases although hyperparathyroidism may be caused by a generalized enlargement of all the parathyroid glands (Albright, Sulkowitch and Bloomberg: Hyperparathyroidism Due to Idiopathic Hypertrophy of Parathyroid Tissue, Arch. Int. Med. 62: 199, 1938). In Albright's 50 Massachusetts General Hospital cases 41 were due to adenoma of a single gland, in 3 cases to two adenomata, and 6 were due to hypertrophy of all glands. Adenoma which may consist of the oxyphil, chief or transitional cells of the gland (Warren and Morgan: A Histologic Study of Parathyroid Adenoma, Arch. Path. 20: 523, 1935), is usually confined to one gland and is palpable. However, considerable ingenuity may be required to find the adenomatous parathyroid. The surgeon may have to split the sternum as the parathyroid may be as low as the lower border of the thymus. The parathyroid with adenoma may be imbedded in the thyroid. Cochrane (Parathyroid Adenoma. Report of Three Cases, New England, J. Med. 224: No. 23, June 5, 1941) believes that resection of the adenoma rather than complete removal is the operation of choice (to avoid tetany). Removal of the adenoma results in a remarkable reversal of bony changes with restoration to practical clinical normal. I have observed but one of these cases after operation, but it was one of the most awe-inspiring clinical experiences of my life.

The disease may begin with spontaneous pathologic fractures or with complaints of rheumatism. As it progresses nearly all the bones become decalcinated and the seat of cystic tumors. Strock (New England J. Med. 224: No. 24, June 12, 1941) calls attention to the mouth in hyperparathyroidism, the changes consisting in visible or palpable tumors of the jaw, malocclusion or distortion of the normal arrangement of the teeth, cystlike cavities of the jaw, osteoporosis, closely meshed trabeculae, and absence of the lamina dura. Prognathism may occur. Remarkable is the statement about one patient that "the bones had been so depleted of calcium and phosphorus that it was possible to

mold the shape of the jaw by the pressure of one's fingers, yet there was no apparent lack of calcium in the teeth, clinically or by radiogram."

Mild degrees of hyperparathyroidism may occur. The milder the disease, the less abnormal will be the blood chemistry changes. But since cases with slight chemical changes may be fatal, it is important to recognize them.

Chemical changes precede probably in all cases the bony destruction. In hyperparathyroidism there is a high blood calcium, and high blood phosphatase (which drop after tumor removal). Blood phosphorus findings are irregular, usually low. These conditions lead to calcium deposits in the soft tissues, particularly kidney stones. The walls of the stomach and intestines are infiltrated, possibly accounting for the attacks of vomiting and the constipation.

Hyperparathyroidism can occur without bone destruction. Ordinarily hyperparathyroidism causes the patient to be in negative calcium balance: if so, bone disease develops. But if the patient ingests enough calcium to replace that lost in the urine and feces, the balance is not negative and no bone disease develops. For all practical purposes, Albright says, this comes down to whether the patient drinks enough milk (Albright and Sulkowitch: Cases of a Minimal Degree of Hyperparathyroidism, *Am. J. M. Sc.* 193: 800, June, 1937).

Differential diagnosis of *osteitis fibrosa cystica* must be made from osteoporosis, osteomalacia, Paget's disease, and multiple myelomata.

Infantilism may be due to many causes. Hirschsprung's disease and congenital heart disease, for instance, are examples of nonendocrine infantilism. (Not that infantilism is necessarily always associated with either of them.) Cretinoid infantilism, hypopituitary infantilism, Brissaud's type of thyroid infantilism, and the Lorain-Levi type of infantilism are recognized as much on account of their lack of sexual and mental development as by skeletal changes. The Lorain-Levi type sometimes responds to pituitary replacement therapy and sometimes to thyroid.

2. Changes in Fat Metabolism—Fatness and Leanness

The old classification of endogenous obesity and exogenous obesity completely satisfies no one. There is no gainsaying such metabolists as Newburgh, who says that all obesity is due to eating too much, and reduces his patients by diet alone. There is also no gainsaying the endocrinologist who says he can reduce them faster by the use of endocrine hormones. In 41 of Mean's cases of exogenous obesity the basal metabolism was normal. There is evidence to show that some cases of exogenous obesity under work produce less heat than normal. The fatty acid—glucose ration of 3 to 1—can be oxidized without a ketosis, which indicates a metabolic abnormality.

Endogenous obesity has been divided into the hypothyroid, hypopituitary, and hypogonad forms.

The hypothyroid is described as a general distribution of fat, with perhaps certain localized accumulations of fat—a pad in the back over the seventh cervical and upper dorsal region, large breasts, large buttocks, and stocky fat

legs. These are not frank cases of myxedema, the subcutaneous deposit being fat and not myxomatous tissue. But myxedema presents the same sort of distribution of excess tissue.

There is no good experimental justification for saying that there is a separate type of obesity due to insufficiency of the hypophysis. After ablation of the hypophysis, animals become thin, not obese. While not any more scientific, perhaps, it is probably better to refer to the other great type of endogenous obesity as hypopituitary-hypogonad.

The hypopituitary-hypogonad type of obesity occurs characteristically in women and after the menopause. The excess fat is distributed in the trunk and upper extremities from the neck to the knees, particularly about the girdle, with a large abdominal apron, small buttocks, trochanteric pads, hanging fat on the thighs and upper arms, fat pads over the seventh cervical spine, small breasts, small legs, arms, feet and hands, and delicate facial features.

MIXED TYPES.—Thyropituitary types of obesity occur, producing bizarre caricatures of the human form.

Fröhlich's syndrome, dystrophia adiposogenitalia, occurs in adolescent boys and girls, and consists of a general obesity with delayed sexual development. The boys have a characteristic delicate feminine skin, small penis and testes, and lack pubic hair. The pelvis is wide. There is a lack of axillary hair and beard and a generalized distribution of fat with especial abundance or deposits over the hips and in the breasts. The fat is hard and firm. The girls have the same fat distribution and lack of hair development, with an infantile uterus. In both sexes the muscular tonus is low, there is hyperextensibility of the joints. The basal metabolism is normal, the sugar tolerance is increased. The mentality is high. Some cases, but those in the great minority, are associated with craniopharyngiomata.

Fröhlich, in his original case, noted: An individual well developed and well nourished. Rapid gain in weight after the eleventh year. The fingers thick with the exception of the terminal phalanges. The hands are plump. The osseous system is not involved in the increase in size. The most marked collections of fat are in the skin of the trunk, especially the abdomen and region of the genitalia. The penis, which is otherwise normally developed, is so hidden between masses of fat that the genitalia approach the feminine type. The testicles are palpable in the masses of fat and are infantile. There are collections of fat in the region of the nipples. There are no hairs in the axillae and only a few hairs on the genitalia. The hairs on the skull are brittle, short, scanty, and since the onset of the illness constantly falling out. The skin is dry and somewhat harsh. In many places, especially on the trunk, it can be lifted in thick folds with the fat underneath.

Myxedema produces an excess deposit of tissue which is not, as the name indicates, fat. Boyd (*Textbook of Pathology*, Lea & Febiger, 1934) writes. "The disease owes its name to a solid pseudocedema of the skin and mucous membranes caused by infiltration with a mucinlike substance, so that the tissue appears to be myxomatous. It is this infiltration which serves to iron out the expressive wrinkles and folds of the face, so that all the patients have a strong

family resemblance." The distribution of this tissue is particularly in the subcutaneous tissue of the face and in the hands, arms, and feet, though it may be universal.

The myxedema patient has:

1. Puffiness of the face and eyelids.
2. Swelling of the tongue and pharynx, making the speech hoarse, slow, and slurred.
3. Roughness and dryness of the skin, with a tendency to chilly sensations.
4. Falling out of the hair all over the body, producing areas of alopecia (sometimes complete baldness), absence of axillary and pubic hair, and "moth eaten" appearance of the eyebrows.
5. Poor memory and mental sluggishness generally.



Fig. 16.—Nodular goiter with myxedema in twins.

6. Constipation.
7. Reduction of basal metabolism.
8. Anemia which may be mistaken for pernicious anemia.
9. Hypertension and albuminuria, which may deflect the diagnosis from the true one.
10. Myxedema heart which may be mistaken for hypertensive heart.
11. Loss of sexual libido, and cessation of menstruation which may deflect the diagnosis to the menopause.

In the description of his original cases Gull noted:

"To those about such a patient the whole morbid condition is likely to be attributed to indolent habits, and the apparent incapacity for exertion to be deemed dependent on mere inertness of the will. There is certainly a degree of habitual and mental indifference.

"The menses ceased, the patient became insensible and more and more languid, the face altered from oval to round, much like the full moon at rising. The cheeks tinted of a delicate rose-purple, the cellular tissue under the eyes loose and folded. The lips large and of a rose-purple, the alae nasi thick, the rest of the nose depressed. The tongue broad and thick, the voice guttural. The hands peculiarly broad and thick, spadelike, as if the whole texture were infiltrated. The integuments of the chest and abdomen also large and fat, with slight traces of edema over the tibiae, but this not distinct, and pitting doubtfully on pressure. Heart's action and sounds normal, pulse 72, breathing 18."

Myxedema constitutes one of the great reproaches of diagnosis. There are few important diseases so commonly overlooked by well-qualified physicians. This in spite of the fact that every textbook of physical diagnosis has a photograph of a typical case. And it is the typical case that is missed, not the formes frustes. The formes frustes are easy to diagnose because the diagnostician usually makes them up out of his imagination as he goes along. But curiously when he comes to the real thing he falls down.



A.



B.

FIG. 17.—Myxedema. A, before treatment and B, three months after treatment.

One reason is that the disease is an imitator. The patients are middle-aged in most cases and appear to have pernicious anemia or nephritis, and the blood and urinalysis confirms this impression. Or the hypertension and heart findings look like cardiac failure.

Another reason is that the patients talk slowly and this tires the diagnostician's patience—it prolongs the time before he can put them under a machine which will grind out the diagnosis like a factory. The responses of the myxedematous patient are slow and freighted with melancholy. Heaven only knows how many of them have gone to an institution with the diagnosis of "involutional melancholia"—and stayed there.

My friend, Dr. Cyrus Sturgis, Professor of Medicine at the University of Michigan, tells of a return visit to his home town and how he looked up an old friend, a retail merchant. When the doctor entered the store, the merchant slowly got up from his seat in the back and dragged himself to face his visitor. Recognition was slow. He said he had been sick. He had consulted the physicians at a famous clinic who told him he was jaundiced and removed his gall bladder. But he was not getting along any too fast. And, as Dr. Sturgis says, a perfectly typical myxedema facies was looking at him.

For a similar experience of my own see p. 202. And by all means read "A Case of Myxedema" (Brush and Cornell: Arch. Int. Med. 11: 530, 1913).

Plummer (West, J. Surg. 5: 85, Feb., 1942) points out that not all myxedema patients are obese; in 4 out of a series of 200 myxedema patients the weight was below the theoretical normal. But, the photographs which he presents show fat pads or myxomatous pads in the face, especially under the eyes.

Abnormal leanness, as an endocrine manifestation, is seen in Simmond's disease, or hypophyseal cachexia. It occurs in females preponderantly at the ratio of 7 to 4. The typical case is near forty years of age, either in a postparturient condition or with some pelvic disorder. Pathologically, there is gross destruction of the anterior pituitary. Sheehan (Quart. J. Med., New Series, 8: No. 32, Oct., 1939), in a series of cases, found that there was a postpartum necrosis which he believed occurred at delivery, which is invariably complicated by collapse, usually as a result of severe hemorrhage. Some cases are caused by sclerosis associated with gonadal dysfunction. In the male, tuberculosis, syphilis, and skull fracture have been noted as the starting point for symptoms. The outstanding symptoms at onset are marked emaciation, cachexia, weakness, premature senility, loss of pubic and axillary hair, amenorrhea, genital atrophy, dry skin, decay of teeth, atrophy of the breasts, and subnormal temperature. Appetite disappears and thirst is diminished. Low basal metabolic rate, low fasting blood sugar, normal blood, low gastric acidity are the laboratory findings. Mental depression is extreme and finally coma ends in death. (See Escamilla and Lissner: J. Clin. Endocrinol. 2: No. 2, Feb., 1942.)

3. Sexual Manifestations of Endocrine Disease

a. The masculinizing tumors are basophile adenoma of the pituitary (Cushing's syndrome), cortical tumor of the adrenal ("syndrome genito-surrenale"), arrhenoblastoma of the ovary and "oat cell" tumor of the thymus. All are characterized by the rather sudden development of facial and general hirsutism and other features of masculinity.

Cushing's syndrome was originally ascribed to *basophile adenoma of the pituitary*. The basophile cells were on theoretical grounds supposed to be the sex-maturing cells of the pituitary. It was predicted that a young woman of twenty who began to have a profuse menstrual flow with obesity and hirsutism would show a disturbance of the basophile cells of the pituitary. She died of an intercurrent infection and a small pituitary adenoma, made up of basophile cells.

Cushing described the syndrome as follows: (1) a rapidly developing and often painful adiposity confined to face, neck, and trunk; (2) a tendency to kyphosis, from a softening of the tissues of the spine; (3) sexual dystrophy shown by early amenorrhea in the females and impotence in the males; (4) hypertrichosis of the face and trunk in all females and preadolescent males; and possibly the reverse in adult males; (5) a dusky, or purplish appearance of the skin with marked abdominal striae; (6) vascular hypertension; (7) tendency to polycythemia; (8) backache, abdominal pains, fatigability, acrocyanosis, ecchymoses, slight exophthalmos, dryness of the skin, polyphagia, polyuria edema of the lower extremities. The adenomas are small and seldom produce changes in the sella.

The conception that the syndrome is specific has been criticized on the ground that adrenal cortex tumors have been found in apparently typical cases. The influence of the pituitary cells on the adrenal cells may account for this. Cushing's syndrome has been described when only adrenal tumor was found. But the two syndromes are so similar clinically that it is like the obverse and reverse of the same coin.

The *adrenogenital syndrome* may be due to tumor or hyperplasia of the adrenal cortex. Grollman denies the existence of estrogenic tumors in the cortex, and postulates that all masculinizing tumors arise from special "androgenic" tissue, functionally distinct from the rest of the cortex. If they occur in adult life, the cortical tumors or hyperplasia predominate in the female and result in masculinity: coarse, greasy, acneform skin, marked hirsutism, especially on the face, atrophy of the uterus, ovaries, and breasts, and enlargement of the clitoris. Gordon Holmes' patient observed for two years before operation, during which masculinization became extreme, reverted completely to feminine characteristics two months after operation and remained so for nine years. In this syndrome striae of the skin of the abdomen similar to Cushing's disease, develop.

Arrhenoblastomata of the ovary are rare tumors. About fifty have been recorded. They are derived from the primordial testicular cells in the ovarian medulla: about 80 per cent are benign. They vary greatly in size, up to large cystic masses. They produce masculinization of the voice, hirsutism, etc. Most of the symptoms (except the voice changes) regress on surgical removal.

Oat cell tumors of the thymus are so rare that they can be disregarded in practical diagnosis.

It will be seen that differential diagnosis of the first three syndromes is very difficult. The finding of a tumor in the ovarian or in the kidney region may be final. A few other points may be helpful. In adrenocortical disease there is a glucose tolerance curve of the diabetic type, but it is not much influenced by insulin. (The eosinophilic cells of the pituitary apparently secrete a hormone that inhibits insulin—the glycotropic hormone of the pituitary. So apparently do the adrenocortical cells under certain circumstances, perhaps when influenced by the pituitary.) In Cushing's syndrome amenorrhea is one of the outstanding symptoms. The clitoris is not likely to be

enlarged in Cushing's disease. In Cushing's disease and adrenocortical cases there are high urine ketosteroids, in arrhenoblastoma low values. Atrophy of the breasts has been more often reported with arrhenoblastoma than with Cushing's syndrome. "In Cushing's disease you never get virilism, rather hirsutism, without other evidence of virilism." (Albright, Fuller: *New England J. Med.* 221: 351, Aug. 31, 1939, *Massachusetts General Hospital Case Records.*)

b. Feminizing Endocrine Disorders.—*Fröhlich's syndrome*, the most frequent cause of feminization in the male, has been described above.

Mumps with destructive orchitis produces a syndrome that has not been very extensively described. The worst results come from the onset of mumps in late adolescent life, ages seventeen to twenty-one. Generalized obesity, high pitched voice, lack of beard, impotence or sterility, and tendency to fatigue and fainting spells are characteristic. I have seen gynecomastia so extreme that the man's breasts hung down to his pelvic rim.

Chorionepithelioma of the testes is a very malignant tumor, the cells of which evidently secrete the hormone of the placenta cells. It produces marked gynecomastia. It usually proves fatal within a few months after its first appearance. There are gonadotropic substances in the urine, which give a positive Aschheim-Zondek, or Friedman test. Sometimes the tumors arise extragenitally (Heaney: *Extragenital Chorionepithelioma in the Male*, *Am. J. Cancer* 19: 22, 1933).

Chromophobe adenoma is the most frequent pituitary tumor. The chromoplate cells have no known function. The tumor grows at such a rapid rate that it compresses or destroys the other pituitary cells, causing symptoms of hypopituitarism. The most serious effects of the tumor are local with compression of the optic chiasma. Headache and other compression symptoms occur, but the great danger of these tumors is that the diagnosis will not be made and the tumor removed before blindness occurs.

Chromophobe adenoma occurs about equally in the sexes and usually between the ages of twenty and fifty. Sluggishness, sensitivity to cold, atrophy of the skin, and fatigability are symptoms that may readily go disregarded. In the male the hair on the face becomes scant, and shaving is infrequently required. The pubic hair shows a female distribution. An adiposity of the feminine type appears. There is loss of libido. Menstruation ceases in the female. Temperature, pulse, and basal metabolism are subnormal.

Vines and co-workers have advanced a theory of an adreno-genital syndrome which postulates that the adrenal cortex is "a potentially bisexual accessory sex gland, largely controlled by the pituitary and capable of secreting simultaneously androgens or estrogens, the one or the other being in excess." (Vines et al: *The Adrenal Cortex and Intersexuality*, London, 1938, Chapman & Hall.)

c. Sexual Precocity.—A rare *teratomatous tumor* of the pineal gland is associated with sexual precocity in boys. Hoerax (*Arch. Neurol. and Psychiat.*

35: 215, 1936) was able to collect only 25 recorded in the literature up to 1936. It occurs exclusively in males and results in true precocity with a large penis, well-developed testes, signs of sexual function, such as erections, emissions, and interest in the opposite sex. The ages of the patients have been from eighteen months to five years. At five years, the subjects may grow in height with adult body configuration and hair distribution. The tumor, besides the constitutional effects, produces local pressure symptoms with eye signs of loss of pupillary reaction to both light and accommodation and an inability to move the eyes upward, downward, or laterally: occlusion of the aqueduct of Sylvius and pressure on the vein of Galen may give hydrocephalus, headaches, and somnolence. Pressure on the cerebellum may lead to suspicion of an intracerebellar tumor.

It is not considered that the signs of sexual precocity are due to abnormal secretion of the gland so much as to involvement of nerve centers which influence the sexual organs. To support this view Saar has reported precocity in glioma (*Pubertas Praecox bei Gliom des Zwischenhirnes*, Frankfurt, *Ztschr. f. Path.* 50: 541, 1937). Furthermore, it is well known that tumors of the pineal (pinealoma) may occur without producing precocity.

The status of the pineal gland as an endocrine organ is in debate. In man it has three stages of development: the first up to the sixth month of fetal life; second, the period of progressive development up to the seventh year; after that the third stage is a period of involution—in which stage the epithelial cells largely disappear and may be replaced by "brain sand." The idea was advanced that it corresponded to the third eye in certain species of reptiles, but this has been superseded following the researches of Tilney and Warren, who showed that it is not a vestige but truly epithelial and glandular. It is probably the parapineal which evolves into the parietal eye in the reptiles. (See article by Tilney on Pineal Gland, in Cowdry's *Cytology*—Paul B. Hoeber, 1928.) The functions of this epithelial structure, whether endocrine or otherwise, are still undetermined. (See Davis and Martin: *The Results of Experimental Removal of the Pineal Gland in Young Mammals*, *Arch. Neurol. and Psychiat.* 43: 23-45, 1940.)

In the course of treating young boys for undescended testes with gonadotropin striking increase in the growth of the penis and growth of pubic hair has been observed.

Precocity in the female occurs in rare cases when the ovaries mature in early childhood. There is menstruation as early as five years, growth of the mammary glands, axillary and pubic hair, and ovulation. (See Grollman: *Essentials of Endocrinology*, Philadelphia, 1941, J. B. Lippincott Co., p. 420.)

Polyostotic fibrous dysplasia is characterized by precocious puberty (particularly in females), symmetrical lesions of the bones, and dystrophic changes in the skin. (Albright, Seoville and Sulkowitch: *Endocrinology* 22: 411, 1938.)

Adrenal virilism, puberta praecox of the adrenogenital syndrome, affects males most markedly, emphasizing all the masculine secretory elements of the

adrenal cortex. Hoskin thinks that the case of Craterus, brother of Antigonus in classical antiquity is an example: "The subject was an infant, a young man, a mature man, an old man, was married and begot children, and all in the space of seven years." The youngest case recorded is that of Foster. Up to six months development had been normal, but at the age of one year extreme virilism was marked. The penis had enlarged, the prostate had reached the size of a walnut, and emissions were constant. Pubic hair had developed, there was acne on the face. The voice was deep pitched. The bony development was far ahead of the chronologic age. At the chronologic age of one, his dental age was three, his bone age five years, and his sexual age eighteen years. The testes were not larger than his age. A tumor the size of a golf ball was found above the right kidney at exploratory operation. Its removal was postponed and at the second operation the patient died.

In females the adrenogenital syndrome before puberty produces a combination of accentuated female and male characteristics. There is precocious menstruation, premature growth, and possibly later face hair growth and enlargement of the clitoris.

d. **Eunuchism and Eunuchoidism.**—Castration in the male is a rare event in modern civilized communities; it is usually the result of accident or an act of revenge. Before puberty atrophy of the testes may result from mumps. A religious sect, the Skapts, in Rumania, who perform castration as part of their ritual, have been studied. (Koch: *Ueber die Russisch-Rumänische Kast-ratensekte, der Skapzen*, Jena, 1921, G. Fischer.) From this study we have the only facts concerning the results of castration, recorded by modern endocrinologic methods.

Castration before puberty produces an excessive growth of the long bones, with a lack of proportion between the length of the trunk and the extremities which are longer than normal. The pelvis is female. The skull is acromegalic. There is persistence of the epiphyseal synarthroses beyond the normal age. The larynx is small, the voice feminine. The pubic hair is of the female type, and the hair on the face is scanty. The mammary glands are of the enlarged virginal type. The subjects are shy, effeminate, and high strung. Obesity, the popular form of representation of the eunuch in pictorial art, is more likely than not to be conspicuous by its absence.

Castration after the development of mature adult life makes very little somatic and usually, except for fertility, very little sexual change. All the adult castrates I have seen—one had chopped off his testicles after the birth of his ninth child, and one had invaded the domestic sanctity of a policeman's home—have retained their masculine characters, and their virtuosity at sexual intercourse was a subject of boastfulness.

Female castrates before puberty have not, so far as I can find, been studied. After puberty cases used to be found more commonly than they are now (in the great days of gynecology, the heyday of ovariectomy), and I have known a good many in my time. If the tubes are left intact they usually menstruate, at least for a time after operation. There is never any discernible change in secondary sexual characteristics nor in libido.

The gonads seem to exert an anti-hormone effect on the growth secretion of the anterior pituitary, at least to judge by clinical observations (See von Drigalski, Wolf, and Diethelm: *Regressive Skeletveränderungen bei hypophysären Hochwuchs*, Klin. Wchnschr. 16: 628, 1937.) The gigantism of the eunuch is a case in point. There is an important clinical class of patients, if we may consider importance to be measured by the number of patients and the frequency with which they consult the clinician, of young people, especially girls, who grow too fast. In the families of the proletariat this does not cause so much concern but among the nobility and gentry, saturated as they are of late with the golden-voiced popular literature of endocrinology, a girl who reaches five feet eight and then goes on growing causes some concern. In these girls endocrinologists have found that if they can get them to menstruate, growth will cease. The best preparation for this is probably stilbestrol (von Haam, Hammel, Hardin, and Schoene: *Clinical Studies on Stilbestrol*, J. A. M. A. 115: 2226, Dec. 28, 1940). In the male this effect has been duplicated in the case of Currier, Frantz, and Vander Meer (J. A. M. A. 117: No. 7, Aug. 16, 1941) a boy of 11 years, 5 feet 11½ inches tall, whose growth was practically stopped over a period of two years with testosterone propionate.

Eunuchoidism.—Cryptorchidism represents a common type of partial eunuchism. The testes can develop normally only in the scrotum. With cryptorchidism the secondary sexual characters usually develop normally, but the penis is small. In mature life they are impotent and sterile. When the secondary sex characters fail to develop normally, a eunuch-like type of skeletal growth occurs. Many cases are helped by testosterone propionate.

Mumps with the complication of orchitis often produces a eunuchoid type of individual. Whether eunuchoid characters develop depends, of course, on how much destruction of testicular tissue the orchitis produces. Careful endocrine study of this group of cases has never, so far as I know, been made. I know, for instance, of no clinical experiments to treat them with testosterone or other hormones. I have seen and examined a number of cases, but have never had the opportunity of making a careful clinical study of them. They present most puzzling physical characters. In general they resemble Fröhlich's syndrome—obese feminine body. And here is the first puzzling feature, because we recognize not obesity but leanness as the characteristic of the eunuch. These individuals look like the eunuchs of imaginative literature and art. They have decided secondary sexual characters—high-pitched voices, mincing walk, feminine interests, scanty facial and body hair. One, as I have noted above, had the most exaggerated gynecomastia I have ever seen.

The problem is whether these signs are due to lack of testicular internal function or whether there is an associated destruction of cells in the hypothalamus with adrenal-cortical degeneration.

e. Menstrual Disorders of Endocrine Origin.—Segal, Steinberg, Schechter, Colton and Pastor (Am. J. Obst. & Gynec. 41: 979, June, 1941) in a series of 125 patients found the incidence of menstrual disorders due to certain endocrinopathies as shown in the accompanying table.

INCIDENCE OF MENSTRUAL DISORDERS

DISORDER	NUMBER OF CASES	RELATIVE INCIDENCE (%)	INCIDENCE IN PATIENTS (%)
Dysmenorrhea	65	30.0	52.0
Oligomenorrhea	44	20.0	35.0
Hypomenorrhea	33	15.0	25.0
Premenstrual tension	24	11.2	19.2
Amenorrhea	19	8.9	15.2
Menorrhagia	11	5.3	8.8
Hypermenorrhea	10	4.7	8.0
Polymenorrhea	6	2.9	4.8
Metrorrhagia	4	2.0	1.6
Total	215	100.0	169.6

INCIDENCE OF ENDOCRINOPATHY

DIAGNOSIS	NUMBER OF CASES	RELATIVE INCIDENCE (%)	INCIDENCE IN PATIENTS (%)
Hypopituitary	70	43.8	58.3
Hypogonad	37	23.1	30.8
Hypothyroid	36	22.5	30.0
Hyperpituitary	7	4.4	5.8
Hyperthyroid	4	2.5	3.3
Hypoadrenia	2	1.85	2.7
Virilism	3	1.85	2.3
Total	160	100.0	132.8

Endocrine therapy produced improvement in over 50 per cent of the patients treated.

Menstruation begins most frequently, according to a large group of statistics, at thirteen years (Engle and Shelesnyak: *Human Biology*, 1934). Five to ten per cent of normal individuals begin to menstruate between eleven and twelve years of age. Five per cent of normal girls begin to menstruate at fifteen or sixteen years of age. Delay to sixteen or even to twenty years is compatible with childbearing. The unique but authenticated case of the Peruvian girl, Lina Medina (Lozada: *La Reforma Medica*—306, May, 1939), who menstruated at seven months and gave birth to a 6½ pound boy by caesarean section at five and one-half years of age, shows what is possible at the other end of the scale. The normal range of onset of menstruation is, therefore, between eleven and sixteen years of age.

With the establishment of the menarche there is a gradual development of the genitalia, but the complete physiologic changes may require ten years. Before the establishment of the menarche, however, the early changes of puberty are initiated by the pituitary with the beginning of secondary sex characters in the breast, increase in the size of the follicles of the ovary, and increase of estrogens in the urine.

Ovulation is not a necessary part of menstruation. The first menstrual discharges are often anovulatory. In adult women who become obese with an accompanying cessation of menses, pregnancy may occur when no menstrual discharge has appeared for a year or more.

Normally ovulation occurs on the twelfth day after the previous menstrual discharge. During the ripening of the ovum the endometrium is stimulated to growth by the secretion from the follicular cells, *estrogen*. After the discharge of the ovary the cells of the corpus luteum secrete *progesterin* which causes the proliferative endometrium to grow, with the formation of decidual cells. If fertilization of the ovum occurs, the cells of the corpus luteum of pregnancy and the placenta produce estrogens, progestins, and the gonadotropic hormone which inhibits ovulation and presides over the other functions of pregnancy.

The stage and state of menstruation are reflected in the vaginal epithelium and can be determined by the vaginal smear method of Papanicolaou (Am. J. Anat. 52: 519, 1933). The findings at the time of ovulation consist of epithelial cells, the disappearance of polymorphonuclear leucocytes, and the presence of mucus. In primary amenorrhea the epithelial cells are atrophic and there is an abundance of leucocytes.

Amenorrhea.—Amenorrhea is divided into primary and secondary. Primary amenorrhea is lack of menstruation at a time of life when it is to be expected. Secondary amenorrhea is cessation of the menses after establishment of the menarche. There are few physical or laboratory signs accompanying either of these states which help the clinician determine whether they are caused by ovarian, pituitary, or thyroid insufficiency. The use of therapy alone and the interpretation of its results are the only indications of diagnosis, and that is a speculative broken reed. In primary amenorrhea if there is accompanying dwarfism, the pituitary is implicated. Secondary amenorrhea may occur in emotional upsets, malnutrition, obesity, and hypothyroidism as well as ovarian deficiency.

Functional uterine bleeding is equally obscure so far as diagnostic conclusions are concerned. It is a common condition and has considerable importance diagnostically in that the clinician can often prevent unnecessary operations and radiation therapy.

f. The "Seabright-Bantam" syndrome consists in failure of an end organ to respond to a hormone, even though the hormone is produced in good quantity. It derives its name from the fact that the male Seabright bantam has female feathering, although there is no abnormality in the internal secretion of the testis. The difficulty lies in the response, or lack of response, of the end organ. Another example is the absence of beard in the American Indian. Examples in clinical practice are: (1) patients with low basal metabolic rates, but no hypothyroidism: the response to thyroid medication is poor, requiring large amounts to obtain results; (2) pseudohypoparathyroidism—patients with normal parathyroids and presumably normal secretion with a low blood calcium which does not rise with administration of parathyroid extract. One of Albright's patients had epileptic-like seizures. There is a characteristic physiognomy consisting of a round face and a thick-set figure. The hand is spadelike and shows the index finger longer than the others. (Albright, Burnett, Smith, and Parson: *Endocrinology* 30: 922, June, 1942.)

4. Anomalies of Intelligence

Anomalies of intelligence are discussed in various other sections of the book.

5. Eye Changes in Endocrine Disorders

Exophthalmos and the eye signs of hyperthyroidism are discussed in the section on the physical examination of the eyes (p. 259).

The tonus of the vegetative nervous system may be under the control of the endocrine glands. This is often reflected in the state of the eyes. Goldzieher (*Practical Endocrinology*, D. Appleton-Century Co., 1935) gives a useful table of the eye signs in imbalance of the vegetative nervous system.

STRUCTURE	SYMPATHETIC STIMULATION (PARASYMPATHETIC RELAXATION)	PARASYMPATHETIC STIMULATION (SYMPATHETIC RELAXATION)
Upper lid	Retracted, lagging	Ptosed, puffy
Conjunctiva	Vessels constricted	Vessels dilated, edema
Cornea	Complicatory only	Dystrophic changes
Pupil	Dilated	Contracted
Palpebral fissure	Widened	Narrowed
Lacrimal gland	Increased lacrimation	Decreased lacrimation
Position of globe	Proptosed (exophthalmos)	Retracted (enophthalmos)
Tension	Hypertension	Hypotension

Eye signs and symptoms may occur from pressure on the optic chiasm, in cases of pituitary tumor, particularly the craniopharyngiomata. The nature of the changes will, of course, depend on the location of the pressure, but the rule is an hemianopsia, unilateral or homonymous, particularly temporal blindness; limitation of vision suggests pituitary tumor more than anything else. Optic atrophy on one or both sides, temporal pallor, bilateral papilledema are found by ophthalmoscope, and headache, vomiting, deafness, facial twitching, facial paralysis, syncopal attacks have been observed to accompany them. (See Engelbach: Pituitary Tumor, *M. Clin. North America* 7: No. 5, and de Schweinitz: *J. A. M. A.* 81: No. 21, Nov. 24, 1923; and Lillie: *J. A. M. A.* 81: No. 21, Nov. 24, 1923.)

Cornea and Conjunctiva.—Keratoconus, a thinning out and weakening of the corneal stroma, with a bulging forward and rupture of Descemet's and Bowman's membranes, is associated with pituitary adiposogenital dystrophy.

Keratitis is described as due to endocrine dystrophies such as myxedema and hypo-ovarian conditions.

Follicular conjunctivitis is described as part of the menopause, or in men after gonadal activity is over.

Cataract, or at least cloudiness of the lens, is described in tetany and after thyroidectomy, apparently when parathyroid tissue was also removed. Cataract occurs in about 5 per cent of diabetes mellitus cases, but is really, in most instances, simply a senile or degenerative cataract. Diabetes probably aggravates the tendency to cataract development, as it aggravates arteriosclerosis and angina.

Glaucoma is aggravated or an attack precipitated by a hyperthyroid state or by the climacteric in male and female.

6. Skin in Endocrine Disorders

The nutrition of the skin is noticeably affected in many endocrine disorders: the coarse, dry skin and coarse hair of myxedema, the moist, soft skin of exophthalmic goiter, the fine lanugo hair and delicate thin skin of dystrophia adiposogenitalis, etc.

The striae, particularly on the skin of the abdomen, in Cushing's syndrome (basophile adenoma of the pituitary) are notable in all the classic photographic illustrations of the condition.

Pigmentation of the skin and mucous membranes is the outstanding sign of Addison's disease. Thomas Addison, in the original and very mixed-up account of the disease which bears his name (in the first part of the paper he described pernicious anemia, but failed to identify the gastric atrophy at autopsy), emphasizes the prolonged and insidious onset, the "anemia, general languor and debility, remarkable feebleness of the heart's action, irritability of the stomach and peculiar change of color of the skin occurring in connection with a diseased appearance of the supra-renal capsules." He also mentioned the pearly whites of the eyes and the extreme wasting of the body—"without, however, presenting the dry and shrivelled skin usually attendant on protracted malignant disease." This property of the skin in Addison's disease, fitting "snugly despite the weight loss," results in underestimation or misinterpretation of the emaciation on the part of clinicians, according to Rowntree. Addison also noted that "it is by no means uncommon for the patient to manifest indications of disturbed cerebral circulation," which corresponds to the experience of clinical practice in which the presenting symptoms are often dizziness and syncope. The only clinical features which have been added to the picture since his time are hypotension, a craving for salt, and the tendency to the precipitation of crises in which there is continuous vomiting and diarrhea, and the asthenia and hypotension are often so profound as to result in death.

Addison's description of the pigmentation hardly admits of improvement:

"This discoloration pervades the whole surface of the body, but it commonly occurs most strongly on the face, neck, superior extremities, penis, and scrotum, and in the flexures of the axillae and around the navel.

"It may be said to present a dingy or smoky appearance, or various tints or shades of deep amber or chestnut-brown; and in one instance the skin was so universally and so deeply darkened that but for the features the patient might have been mistaken for a mulatto.

"In some cases the discoloration occurs in patches, or perhaps rather certain parts are so much darker than others as to impart to the surface a mottled or somewhat checkered appearance; and in one instance there were, in the midst of this dark mottling, certain insular portions of the integument presenting a blanched or morbidly white appearance, either in consequence of these portions having remained altogether unaffected by the disease, and thereby contrasting strongly with the surrounding skin, or, as I believe, from an actual defect or coloring matter in these parts. Indeed, as will appear in the subsequent cases, this irregular distribution of pigment cells is by no means limited to the integument, but is occasionally also made manifest on some of the internal structures.

*A.**B.*

Fig. 18.—Alopecia, due to thyroid deficiency, showing result of three months' treatment with thyroid extract. *A*, before treatment. *B*, after treatment.

"We have seen it in the form of small black spots, beneath the peritoneum of the mesentery and omentum—a form which in one instance presented itself on the skin of the abdomen."

Addison did not describe the buccal pigmentations. Chvostek, in his memorable Vienna clinics, would not commit himself to a diagnosis if they were absent. They appear usually in small splotches as blue-black areas on the inside of the cheek, and under the tongue.

There is no better sign of the accomplished clinician than the minute care with which he searches out and assesses the skin and mucous membrane changes for Addison's disease: pigmentation at points of pressure, the zone of garters, corsets, etc.; in the creases of the hands; the marked discoloration of the genitalia; the jet-black freckles, especially likely to be located behind the ears; the scruffiness of the skin over knees and elbows.

The pigment in the skin is melanin. It can be identified by biopsy if such diagnostic maneuver be necessary. No satisfactory explanation has ever been advanced for the pigmentation in Addison's disease.

The involvement of the cortex would make one anticipate some sexual symptoms, but clinically these do not materialize, either for primary or for secondary sex characters.

The association of tuberculosis with Addison's disease is very definite. The pathologic condition found in the adrenal glands is bilateral tuberculosis in over 85 per cent of autopsied cases. Atrophy of unknown origin accounts for most of the remaining cases. Tuberculosis elsewhere in the body was found by Rowntree in all his cases of adrenal tuberculosis—either as pulmonary, lymph-node in lung, ileum, pleural, genitourinary, or osseous involvement. The spinal column is the most frequent site of osseous complication. The tuberculous lesion in the adrenal gland itself is either proliferative or necrotic, is located "rather consistently in two places: either at some distance from the main suprarenal vein in the medulla or deep layers of the cortex or else midway in the cortex between the medulla and the outer surface." Calcification of the gland occurs and may be made out by x-ray studies.

7. Muscular System in Endocrine Disorders

The muscles depend for smooth functioning on the regulation of calcium, phosphorus, potassium, sodium, sugar and water metabolism, and their tone partly determines basal metabolism so, since all of these are involved in the functioning of the endocrine glands, muscular dysfunction occurs in several endocrine diseases.

The tremor of hyperthyroidism is one of the four cardinal signs. The cause of the tremor must in some way be associated with the increased resting metabolism of all the cells of the body. Degenerative changes are seen histologically in the muscle fibers. Creatinine occurs in excess. A correlation between total basal calorie output (a gauge of the level of thyroid activity) and creatinine excretion (a gauge of active muscle mass) has been demonstrated (Talbot, Worcester, and Stewart: *Am. J. Dis. Child.* 58: 506, Sept., 1939).

In contrast to the tremor of hyperthyroidism the muscular movements in myxedema and other hypothyroid states are vermicular.

Sluggish response of the patellar reflex is a regular sign in myxedema.

Tetany is a state of irritability of the neuromuscular system due to abnormal metabolism of calcium, phosphorus, and other inorganic salts. It is relatively common in infants due either to vitamin D deficiency or to disturbance of calcium metabolism from celiac disease, etc.

In adults it is rarer, the causes being lactation with inadequate calcium intake ("wet nurse's contraction"), or removal of too much parathyroid tissue during a thyroidectomy.

The muscular spasm of tetany may involve any muscle group, perhaps most commonly the hand, which becomes stiff and rigid with the thumb adducted and covered with the stiff fingers bent at the metacarpophalangeal joints. The facial muscles are next most frequently affected. In infants generalized convulsions occur.

The division is made between *active tetany* in which there is spontaneous tonic spasm of any muscle or group of muscles and *latent tetany* in which the irritability of the muscles must be brought out.

Latent tetany is demonstrated by the signs of Erb, Chvostek and Troussseau. Erb's sign is elicited by electric stimulation of the muscles. In tetany there is a muscular response to weaker stimuli than in normal muscles. The normal cathode opening response is more than six milliamperes as a minimum, while in tetany it is less than five milliamperes.

Chvostek's sign is a twitch, or spasm, of the facial muscles in response to tapping on the facial nerve at its exit from the stylomastoid foramen anterior to the external auditory meatus. *Troussseau's* sign is performed on the hand muscles but by encircling the upper arm with a blood pressure cuff. When the cuff is compressed, the hand goes into spasm. When the pressure is relieved, the spasm relaxes. In some cases mere pressure by the examiner's hand will elicit the phenomenon.

The biochemical reactions in tetany are complicated. In general, tetany occurs when the blood calcium falls from its normal of 10 to 7.5 milligrams. In tetany due to parathyroid deficiency the blood calcium is low, the blood phosphorus is high, the pH is normal, phosphatase is normal, urine calcium and phosphorus is low, and calcium and phosphorus excretion in the feces is normal. This corresponds exactly to the findings in experimental work: writes Albright, "If one stops substitution therapy with parathyroid extract in a parathyroidectomized patient four cardinal metabolic changes occur. There is first an immediate decrease in the phosphorus excreted in the urine; second, the serum phosphorus rises; almost simultaneously the serum calcium level falls; and finally, with the fall in serum calcium, there is a diminished excretion of calcium in the urine." (Albright and Ellsworth: *Calcium and Phosphorus Studies on a Case of Idiopathic Parathyroidism*, J. Clin. Investigation 7: 183, June, 1929.)

Other causes of tetany besides hypoparathyroidism are rickets, osteomalacia, steatorrhea, renal insufficiency with phosphate retention. This is the hypocalcemia group. The other group is associated with alkalosis, especially alkalosis due to hyperventilation.

In rickets and osteomalacia there is a low serum calcium and a low, or in some instances normal, phosphorus. Serum phosphatase is normal or low in hypothyroidism, high in rickets and osteomalacia. Steatorrhea produces hypocalcemia for the same reason as does rickets—a vitamin D deficiency. vitamin D, being fat soluble, is dissolved in the unabsorbed intestinal fat the chemical findings are, therefore, the same as rickets. In renal insufficiency there is phosphorus retention with a compensatory lowering of the serum calcium. But tetany is more infrequent in renal insufficiency because of the acidosis which inhibits tetany.

Level of Urinary Calcium in Mgs. Per 24 Hours

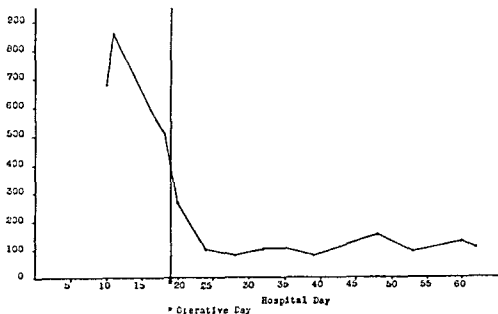


Fig. 19.—Hypoparathyroidism.

In tetany due to alkalosis the urine is alkaline and contains normal amounts of calcium. Gastric tetany is alkalosis induced by the loss of acid from the body from vomiting.

Hypoglycemia results in tremor and trembling. This is the symptom the patient notices in spontaneous clinical hypoglycemia due to hyperinsulinism. Hyperinsulinism occurs in varying degrees of severity. There may be simply a hypoglycemia which is merely an exaggeration of the hypoglycemia that occurs in late afternoon with anyone who leads an active life: the patient complains of "weakness, nervousness and irritability about an hour before dinner, relieved by the meal." In other cases there is a tumor (nesidioblas-

toma) of the islet cells, located most often in the tail of the pancreas, usually single and presenting a characteristic reddish brown hue on inspection. They are associated with hypoglycemic crises of tremor, restlessness, malaise, vasomotor disturbances, annoying sensations of hunger, palpitation and sometimes severe abdominal pain. Coma and death may occur (Malamud and Grosh: Hyperinsulinism and Cerebral Changes, Arch. Int. Med. 61: 579, 1938).

Attempts have been made to connect up myasthenia gravis and the muscular dystrophies to endocrine disorders, but without success. Removal of thymic tumors has resulted in remission of myasthenia gravis, but remissions occur anyway. (Miller: Myasthenia Gravis and the Thymus Gland, Arch. Path. 29: 212, 1940).

8. Disturbances of Sugar, Salt, and Water Metabolism in Endocrine Disease

Diabetes mellitus is an endocrine disease, the symptoms of which can be explained in decreased secretion of insulin and consequent disturbance of carbohydrate and glycogen metabolism.

Diabetes insipidus is a disturbance of water metabolism. It is characterized by the passage of large amounts of urine—two or three gallons being a commonly found amount, and a daily output of ten gallons has been recorded. A patient described by Trousseau passed 43 liters daily. There is naturally thirst which, if denied, is tormenting in its insistency. The urine is pale, of low specific gravity, contains no sugar and little salt—hence insipid. It affects young persons, males more often than females. It may be a part of Fröhlich's syndrome. The nutrition of the body is not otherwise affected. It has a strong hereditary bias. Weil reported 23 persons with the disease among 91 members of one family in four generations. The condition appears to cause no serious consequences and health is maintained for years.

The pathologic lesions responsible for the disease have not been fully agreed upon. That it is simply a degeneration of the posterior lobe, or pars nervosa, of the hypophysis was the early theory, but this cannot always be demonstrated. Injury of the hypothalamus alone also produces diabetes insipidus, and in such cases experimentally the output of urine can be controlled by injections of the posterior lobe extract. Ranson has explained away this apparent dilemma by experiments which indicate that injuries in various parts of the hypothalamus, especially in the supra-optic nuclei, influence the secretion of the posterior lobe. When these centers are destroyed or when the nerve tracts leading from them through the infundibulum to the posterior lobe are cut, the posterior pituitary is no longer capable of producing its water-holding (anti-diuretic) hormone. The anterior lobe then produces its diuretic hormone unrestricted.

Chapter 6

EXAMINATION OF THE HEAD

GENERAL SHAPE OF THE SKULL

Microcephaly.—The slanting and small calvarium of idiocy.

Hydrocephalus.—Large head above the face with separation of the fissures.

Oxycephaly.—Pointed skull.

Anchondroplasia.—Large skull vault, drawing in of root of the nose, and receding upper jaw.

Osteogenesis Imperfecta.—Blue sclera and membranous base of the skull, with islands of bone that can be felt.

Hand-Schüller-Christian Disease.—Diabetes insipidus, exophthalmos, and defects of the skull due to granulomatous deposits.

Pressure of the granuloma on the pituitary accounts for the secondary symptoms, and intracranial pressure may also produce facial palsy, diplopia, ptosis, and sixth nerve paralysis.

I once thought the diagnosis of this condition could never be mistaken, but an experience taught me otherwise. When the bony defect is not immediately evident, the onset may resemble hysteria, brain tumor, syphilis, migraine, or oral sepsis. Loose teeth and swollen gums may mark the onset. Minor trauma may be blamed.

The lesions are well localized, single, soft yellowish or brownish masses which have replaced the bone. There seem to be two types: one, xanthoma-like, consists of foam cells, histiocytes and cells filled with fat droplets; the other, called "eosinophilic granuloma," consists of eosinophilic cells and large monocytes with active phagocytic propensities. They may affect any bones, the ribs really leading numerically. They are easily destroyed by light doses of x-ray, but other tumors recur. The disease perhaps belongs in the same group with Gaucher's, Niemann-Pick, Tay-Sachs, and Gierke's diseases. The prognosis is poor, but Christian's patient recovered completely.

Leontiasis Ossea.—Large maxilla, prominent facial bones, widening of the bridge of the nose, sclerosing of all bones of the skull.

Fibrocystic Bone Disease.—Mostly affects the jaws. Fullness of lower jaw, especially with turning up of the eyes. Skull seems small in proportion to face.

FACE

When the physician is long acquainted with his patient, a glance at the face tells him more than he is ever able to record. These conclusions are based upon instincts so subtle, however, that they escape scientific definition.

The classic facies were described as follows:

Myxedema.—"Features broad and flattened, skin fine and soft, with a delicate rose bloom on the cheeks, the cellular tissue about the eyes thrown

into folds, giving the impression when cursorily looked at of being edematous, lips thickened, tongue large." (Gull, 1873.)

Acromegaly.—"The face presents the appearance of a lengthened ellipse. The cranial vertex is of nearly the same size as the end of the chin. The lower jaw is well developed." (Marie, 1886.)

Exophthalmic Goiter.—" . . . A lump of about the size of a walnut was perceived on the right side of her neck. This continued to enlarge till the period of my attendance, when it occupied both sides of her neck. . . . The part swelled was the thyroid gland. The carotid arteries on each side were greatly distended; the eyes were protruded from their sockets, and the countenance exhibited an appearance of agitation and distress, especially on any muscular exertion, which I have rarely seen equalled." (Parry, 1825.)

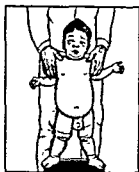
Adenoids.—"The constantly open mouth and a certain stupid expression of countenance are, in the absence of enlargement of the tonsils, characteristic symptoms of post-nasal growths. Davis has recently gone so far as to assert that these formations reveal themselves externally by a modification of the physiognomy, which consists essentially in a deformity of the upper jaw, with projections of the incisor teeth and narrowing of the palatine arch." (Mackenzie, 1884).

Mitral Stenosis.—A malar flush with yellowish pallor of the forehead, nose, and circumoral region.

Dermatomyositis.—Keil (Ann. Int. Med. 16: 828, May, 1942) has called attention to a characteristic facies in this rare affection—swelling of the upper eyelids, with lid narrowing and a peculiar general color of the skin which he calls a "heliotrope blushing," accompanied by telangiectatic areas. (See *Extremities*.)

Swelling of the face alone to the exclusion or practical exclusion of the rest of the body is illustrated (Fig. 20) and little needs to be added to these illustrations. It is not a very common condition and trichiniasis is probably the commonest cause. Therefore, in the presence of any sudden swelling of the face, a differential blood count for eosinophilia is the first step: then urinalysis for acute nephritis. Resnik and Keefer (Significance of Edema of the Face in Myocardial Insufficiency, J. A. M. A. 85: 20, Nov. 14, 1925) called attention to the rare cases of edema confined to the face in myocardial failure. Mackenzie stated, "If the patient leans more to one side than the other, in extreme cases the arm and cheek of that side may become greatly swollen."

Facial Paralysis.—The seventh nerve is the most frequently paralyzed peripheral nerve. The site of paralysis may be infranuclear, nuclear or supranuclear; it is possible and important to distinguish these varieties. The causes of infranuclear paralysis are refrigeration (exposure to drafts, chilling, after shampoo, etc.) and infection (tonsillitis, focal infection, severe cold, erysipelas, syphilis [rare], parotitis, rheumatism). Direct involvement of the nerve occurs in otitis media and mastoiditis and trauma to the base of the skull. Nuclear involvement may come from the Herxheimer reaction in arsphenamine treatment, focal infection, etc. Supranuclear involvement occurs in brain tu-



Nephritis



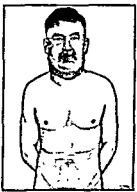
Angioneurotic Edema



Trichiniasis

Cavernous Sinus
Thrombosis

Myxedema

Rupture of Aneurysm
of Ascending Aorta
into Descending
Vena Cava

mors, often subcortical and involving the internal capsule. Congenital defect may occur, and it may be involved with Landouzy-Dejerine atrophy.

The facial nerve arises from its own nucleus in the pons, near the trigeminal and auditory nuclei. It emerges closely associated with the eighth nerve and chorda tympani. In the neck it supplies the stylohyoid and posterior belly of the digastric muscles. The posterior auricular branch supplies the intrinsic muscles of the pinna. In the face proper it supplies the orbicularis palpebrarum, frontalis, corrugator supercilii, attrahens and attollens aurem, the zygomatic muscles, buccinator and muscles of the nose and upper lip, lower lip and chin, and the platysma myoides.

The patient with facial paralysis cannot, therefore, wrinkle the forehead, wink the eye, purse up the lips, whistle, or tense the skin of the neck, and the cheek hangs loose and balloons on respiration. Smell is interfered with probably because the ala nasi closes the nostril. Hearing and taste are involved when the eighth nerve and chorda tympani are involved along with the facial nerve.

Myasthenia gravis is a condition of easy fatigability of the muscles, particularly those of the face, the masseters, and the muscles of deglutition. The facial expression is quite characteristic with ptosis and a blank, sad expression. Difficulty in swallowing and fatigability of all the muscles added to this make the diagnosis quite certain.

For what I have called the *von Neusser syndrome* of sudden swelling and cyanosis of the face and upper part of the body, due to rupture of an aneurysm into the vena cava, see p. 393.

EXAMINATION OF THE MOUTH

This usually furnishes an enormous amount of information. The examination should be conducted under the most favorable circumstances. The slovenly way of taking a patient to a window and poking a wooden tongue depressor into the mouth so that the examiner's hand is in the way of his vision is one of the causes of useless mistakes. The patient should be seated facing the examiner, also seated; either a head mirror and a reflecting lamp and a tongue depressor with a handle, or a self-lighting tongue depressor should be used.

Lips

Look for pallor (you do not see anemia, but you do see pallor). The lips are probably the site of the most delicate index of cyanosis.

Herpes labialis is the most frequent lesion of the lip. It has no significance except that it may, although infrequently, have more serious sequelae—namely, chronic ulcer, chronic fissure, cutaneous horns: all histologically benign, but potentially malignant. The lips are peculiarly likely to have any lesion turn malignant.

Keratosis, thickening of the epithelium, especially in those exposed to wind and weather, is a classical example of a precancerous lesion.

Leucoplakia, a circumscribed or diffuse area of silvery white epithelium (histologically there is a piling up of epithelium), is another. It may run an indolent course for years and then become malignant.

Acute swelling of the lips occurs in angioneurotic edema.

Inflammation of the lips may occur. When the inflammation is confined to the upper lip, it is potentially dangerous, as it may lead to cavernous sinus thrombosis.

Nonmalignant tumors of the lips include hemangioma, epithelioma, papilloma, lymphangioma.

Malignant tumors are all epithelial. Ewing (Neoplastic Diseases, W. B. Saunders, 1922) divides them into *papillary*, which appear as a wart, and *ulcerative* (infiltrating). Hertzler makes the useful distinction of primary, when they appear suddenly on previously, apparently healthy mucosa, and secondary when they implant on keratosis, leucoplakia, benign ulcer, or cutaneous horn. The diagnosis depends upon the history, appearance, and the sandy induration known to the educated surgical touch.

The great important differential diagnosis is between these tumors and chancre. Here the heaven-blessed fact that old people seldom get chancre helps. But young people sometimes get epithelioma, and we have all seen the tragedy of treating one for a chancre until metastasis has taken place. The dark-field and Wassermann tests are, of course, available, but I am not sure but that excision and biopsy should be performed on all ulcerative lesions on the lips after the age of thirty.

Granulomata of the Lips.—Pyogenic and tuberculous granulomata are rare, but do occur.

The lip is overwhelmingly the commonest site of the extragenital chancre. Cole's figures (J. A. M. A. 67: No. 25, Dec. 16, 1916) represent the nearest to average clinical experience: 77 per cent of his cases of extragenital chancres were around the mouth—three on the tonsil, one on the tongue, and forty-three on the lip, out of 61 cases. Seventy-seven per cent occur between the ages of twenty and forty; 90 per cent are in men; 80 per cent in men are on the upper lip and 90 per cent in women are on the lower lip. Why the last, is inexplicable save that with the *baiser d'amour* the man likes to bite the lower lip and the woman, the upper.

Kissing is the mode of spread in almost all cases, and medical literature contains few horror stories to equal those syphilographers relate on this topic. Schamberg's (J. A. M. A. 57: No. 10, Sept. 2, 1911) tale is that of a young man who infected seven young women when they all played a kissing game at a party. One of the young women subsequently infected another young man. Cole relates that a little girl, aged two years, was infected when her uncle kissed her. She infected her father when he kissed her, and her father infected her mother who was pregnant and delivered of a congenital syphilitic child. "There are few things more dangerous," writes Stokes (*Modern Clinical Syphilology*, W. B. Saunders, 1935) "than being kissed by a syphilitic, and all patients with the disease should be strictly enjoined against the practice."

The principal reason for success in making the diagnosis of chancre of the lip is to think about it every time one sees an ulcer on the lip. The three diagnostic points in the diagnosis of chancre—a lesion which is indurated, slow to develop and heal, and associated with a satellite bubo—obtain here. The laboratory examination is final, but you will not have a laboratory examination unless you think of chancre.



Fig. 21.—Ariboflavinosis.

Riboflavin Deficiency.—This is part of the pellagra complex—a macerated linear fissure in each angle of the mouth similar to what used to be called angular stomatitis. The entire lip is usually involved. The lips are scaly, chapped, reddened, and sore. The condition is called cheilosis. The tongue is also usually red, clean, and somewhat swollen.

Buccal Mucosa, Soft Palate, and Uvula.—Mucous patches may appear all over the buccal mucosa and surface of the soft palate, as well as on the lips and tongue. "The typical mucous patch is slightly raised above the surrounding surface, very faintly inflammatory and presents a smooth, round or oval central erosion covered by a flesh-colored to pearly or faintly grayish delicate membrane." (Stokes.) They are painless, usually occurring in the secondary stage. The mouth and anogenital region are the commonest sites of relapse lesions.

Koplik's spots occur in measles. The original description (Arch. Ped. 13. 918, 1896) admits of no improvement: "One of the most, if not the most reliable sign of the invasion of measles. . . . If we look in the mouth at this period (during the first twenty-four to forty-eight hours of the invasion) we see a redness of the fauces perhaps, a few spots on the soft palate. On the buccal mucous membrane and inside of the lips we invariably see a distinct eruption. It consists of small irregular spots of a bright red color. In the center of each spot there is noted in bright daylight a minute bluish-white speck. . . . When seen they can be relied on as the forerunner of the skin eruption. . . . The buccal eruption begins to fade even when the skin exanthemata is at its height. . . . In cases where this eruption has been absent, I have always found that my exclusion of a probable attack of measles was correct."

Pigmentation in Addison's Disease.—This occurs in the form of patches of brown, black or blue discoloration (it is melanin) on the buccal mucosa inside the cheeks, under the tongue, inside the lips and sometimes on the gums. Chvostek in Vienna would not make a diagnosis of Addison's disease unless some pigmentation was present inside the mouth.

The Gums

- McCarthy (J. A. M. A. 115; No. 1, Jan 4, 1941) reviewing 2,300 consecutive cases of oral disease found gingival lesions occurring in the following order of frequency: chronic gingivitis, bismuth gingivitis with pigmentation, gingivitis with hyperplasia, chronic Vincent's gingivitis, acute Vincent's gingivitis, pyorrhea alveolaris, edentulous hyperplasia of gingivitis, mucous patch.

The incidence of Vincent's infection rises and falls. After World War I it was high; in 1944 it was low. Vincent's infection produces a grayish diphtheroid inflammatory line which may run along the gum margin or infiltrate deeper.

Vincent's angina, or properly Plaut-Vincent's angina, was described by Plaut, of Leipzig (Deutsche Med. Schus. 1894), as, "Inspection of the oral cavity which contained many carious teeth, showed a dirty exudate on both medial surfaces of the markedly swollen tonsils, and the left side of the uvula." Vincent (Bull. et mém. Soc. méd. d. hôp. de Paris, 1898) wrote: "The angina is characterized by a grayish, or whitish, pseudomembranous exudate, by the associated fever and occasionally rather marked adenitis."

The simple pyorrhoeic gum is red, and pus can be expressed with the tongue depressor.

If the examiner sees a stippled line of dark pigmentation on the gumma along the tooth border, it is much more likely in these days of intensive anti-syphilis therapy and industrial hygiene to be bismuth than lead. If lead, it is probably in an artisan of some peculiar trade: the last one I saw was in an assistant to a casket maker, the caskets being lined with lead.

The bismuth line and the lead line are much the same except in color. "The edges of the gums attached to the necks of two or more teeth," wrote Henry Burton (*Med. Chir. Tr.*, 1840), who first described the lead line, "of either jaw were distinctly bordered by a narrow leaden-blue line, whilst the substance of the gum retained its ordinary color and condition." The "line" is really a stippling. Bismuth produces a darker pigmentation. Both lines can advantageously be brought out by a reading glass or hand lens.

Deficiency Diseases.—Vitamin A, B (nicotinic acid), and C deficiencies are likely to make spongy, soft gums, scurvy being the classic example. The gums are likely to be attacked by Vincent's or other infection which masks the real condition.

Allergic Gum Reactions.—Thoma (*Oral Pathology*, The C. V. Mosby Co., 1941) refers to and pictures several examples of this—in hay fever, food and tooth paste, cigarettes, etc., contact. The gums are red and swollen for the duration of the attack. (See also Sulzberger and Goodman: *M. Rec.* 143: 17, 1936.)

Drug Eruptions.—A number of drugs taken systemically may produce a reaction of a hypersensitive nature largely confined to the gums. Among those described are aspirin, iodoform (in dressings), the arsphenamines, the sulfa drugs, and for special notation, dilantin. The gum reaction to dilantin appears early in its use and is a signal to stop the drug.

Diseases of the Blood.—Bleeding of the gums occurs in aplastic anemia, secondary anemias (as from benzol especially), chronic infection, purpura hemorrhagica, leucemia, and agranulocytosis. The red, engorged gums of polycythemia may bring such patients first to the dentist.

Tumors of the Gums.—Epulis is a relatively benign giant-celled tumor of the alveolar border, which occurs at all ages in all sexes.

Teeth

In routine inspection of the teeth the examiner will note:

1. The general shape, spacing and structure of the teeth to indicate such things as syphilis (Hutchinson's teeth) diabetes, pituitary disease, defects of calcium metabolism.

2. Malocclusion, loose bridge work, plates, suggesting incomplete mastication and consequent disturbance of digestion and nutrition.

3. Unerupted teeth, crowded teeth, or edentulous mouths which cause mandibular dysfunction, any of them contributing to headache, face ache, neuralgia or Eustachian tube closure.

4. Crowns, sore teeth, loose teeth, loose bridges, all indicating possible focal infection.

5. Caries, gingivitis, pyorrhea.

1. *Hutchinson's teeth* were described as part of a triad pathognomonic of congenital syphilis, the other two signs being interstitial keratitis and labyrinthine deafness. The typical Hutchinson's teeth are those of the permanent set. "The central upper incisors are the test teeth." The characteristics are: (a) Smallness—the teeth stand apart with interspaces and are rounded and peggy in form. (b) Notching—a broad shallow notch on the biting surface. (c) Color—they present a dirty, grayish surface totally destitute of polish and rarely smooth. (d) Wearing down—their softness from deficiency of enamel renders them liable to premature wearing down." (Jonathan Hutchinson: Tr. Path. Soc. London, 1858, and Brit. M. J., 1861.) If all the conditions above mentioned are present, the Hutchinsonian teeth may be considered as pathognomonic. But there are many soft, notched central incisors which are not indications of syphilis. The shape of the tooth rather than the notching is characteristic. Twenty-eight per cent of a series of heredo-syphilitics, according to Stokes, had Hutchinson's teeth.



Fig. 22.—Hutchinson's teeth.

The six-year molars when they present on eruption defective cusps ("Moon molar," "Fournier teeth") are also considered to be indicative of hereditary syphilis.

Even minor degrees of pituitary disease may cause an enlargement of the jaw resulting in wide spacing of the teeth.

Diabetes disposes toward infection in the teeth and gums as elsewhere in the body.

Pregnancy and parathyroid disease predispose toward discernible calcium deficiency.

2. *Malocclusion* and other orthodontic defects of the teeth may result in deficient mastication and consequent digestive and nutritional disturbances. The dentists make much of this, but I confess it has played little part in my diagnostic conclusions. I know half a dozen individuals well who wear plates for esthetic purposes but remove them at mealtime and chew their food with entirely edentulous mouths. Not only have they magnificent digestions, but their nutrition is so good that they are grossly overweight. The only conclu-

sion one can draw from these spectacles is that teeth are entirely unnecessary. Nor is malocclusion and all its accessory conditions any bar to perfect and blooming health.

3. *Crowded teeth* and unerupted teeth as shown by the x-ray. I confess to the greatest amount of skepticism regarding these conditions as a cause of headache, neuralgia, cephalalgia, face ache, etc. They belong in the same category as the reflex disturbances ascribed to deviated nasal septum, retroverted uterus, etc. One sees too many patients with crowded or unerupted teeth who have no neuralgia, cephalalgia or face ache. Most of the patients who have the headaches are neurotics and in 75 per cent, treatment of the teeth makes the headaches worse. "Never monkey surgically with a neurotic" is a good rule. Or to share the reservations of the captain of the *Pinafore*, "Hardly ever."

The only exception I know to this is the perfectly definite and clear-cut syndrome worked out by Dr. James B. Costen of St. Louis. (See Costen: *Ann. Otol., Rhin., Laryng.* 43: 1, 1934, and Costen: *J. Missouri M. A.* 32: No. 5, May, 1935.) This is caused by lack of molar teeth or badly fitting dental plates, permitting overbite. This results in a partial luxation of the mandibular joint, which results in compression of the opening of the Eustachian tube, otic ganglion, and other nerve structures. The patients are seldom aware of any condition or discomfort in the jaw but complain of mild catarrhal deafness, dizzy spells (relieved by inflation of the Eustachian tubes), headache, lower half neuralgia, sinus trouble, tinnitus, and more rarely, Ménière's attacks of prostrating severity. The symptoms are so perfectly logical on the basis of the anatomical disturbances present that the original papers and diagrams should be consulted. And relief follows just as logically the proper restoration of anatomic integrity.

4. *Crowns, sore teeth, loose teeth, loose bridges.*—The physical examination and care of these defects, notations on the record taken in connection with the radiographic evidence of periapical granuloma, etc., help the examiner to make up his mind about focal infection in the teeth as a possible cause of the patient's complaints. The concept of focal infection is so simple that anyone can grasp it in a minute's explanation. Infection arises in some part of the body, such as teeth, tonsils, adenoids, sinuses, gall bladder, seminal vesicles, colon. It is a more or less essential part of the conception that the original focus should be silent. Bacteria or toxins invade the blood stream from this focus and set up inflammation in various remote spots. Thus arthritis, neuritis, muscular rheumatism, ocular infections, peptic ulcer, hepatitis, nephritis, aortitis, myocarditis, coronary disease and thrombosis, and many other conditions are ascribed to focal infection. The bacteria involved—various types of streptococci usually—are postulated to have affinities for certain structures—one for the joints, one for the kidneys, one for the gastric mucosa, etc. The theory looks attractive at first glance: it furnishes the practitioner with a definite procedure to carry out, when he might otherwise be at a loss to do anything of a constructive nature; it is good psychology for the patient and it seldom does any harm. When one comes to examine the validity of the doctrine with

a critical eye, however, the outlines become fuzzy. The procedure has been put to practical test intensively for over a quarter of a century and the results when assessed calmly cannot be said to be brilliant, in spite of the reports of some enthusiasts. In cases of neuritis and myalgia perhaps 25 per cent of favorable results have been obtained, and this is the most successful group. When any considerable organic change has occurred, as in arthritis, coronary disease, aortitis, or myocarditis, of course, no result can reasonably be expected. When the premises of the idea are examined critically by bacteriologic standards, they entirely collapse. But every practitioner must make up his mind about each case of this sort that presents itself. He should read some reviews of the subject, such as Bierring's (*Focal Infection: A Quarter Century Survey*, J. A. M. A. 111: 1623, 1938) and Reimann and Havens' (*Focal Infection*, J. A. M. A. 114: 1, 1940).

In the case of the teeth, however, the practitioner must think long before recommending the sacrifice of a tooth which may be perfectly innocent and doing a useful job and the removal of which is likely to avail nothing. The same considerations do not hold for the tonsils, which can be removed on slight suspicion without impairing the body economy at all. Wholesale removal of all teeth on suspicion is to be condemned no matter what the indications.

5. *Caries, Gingivitis, Pyorrhea*.—"Caries," writes Miller (*Oral Diagnosis and Treatment Planning*, P. Blakiston's Son, 1936), "when present in adolescent and young adult life, indicates either a softening of the enamel, a decalcification of the dentin, or a lowered resistance of the system to bacterial infection. Decalcification is present in parathyroid disorders, hyperthyroidism, thymic dysfunction, pregnancy, and lactation. In diabetes the altered hydrogen-ion concentration of the secretions of the mouth, and within the system, may tend to cause calcium absorption from the dentin."

Parathyroid disorders and thymic dysfunction are very rare and hard to prove. In few diabetics at any stage in the course of the disease is the hydrogen-ion balance seriously disturbed. But dental caries is very common, and it occurs in the absence of hyperthyroidism and in men, where no pregnancy and lactation are involved, as often as in women.

To show the confusion that exists on the subject of dental caries Butler (*Metabolic Factors in the Cause and Control of Dental Caries*, New England J. M. 225: No. 19, Nov. 6, 1941) excerpted from a book called *Dental Caries: Findings and Conclusions on Its Causes and Control* (1939) published by the American Dental Association the following statements from different parts of the book (different authors):

DIET IN GENERAL.—

"There is no evidence that caries is produced by malnutrition or may be prevented by adequate diets."

"Dental caries can arise from metabolic disturbances which can be avoided or corrected through the use of diets high in all recognized nutritional essentials."

Such juxtapositions hardly encourage me to make very definite deductions from the presence of caries. And the same confusion prevails concerning gingivitis and pyorrhea. Certainly these conditions do not produce focal infection and seldom indicate any general bodily disturbance. The sensible conclusion seems to be that there is both a metabolic and a bacteriologic factor in the production of caries: that the metabolic factor probably begins to operate in childhood and adolescence and at this stage the protective foods should be in the diet in abundance; but that the outstanding factor is still infection by the *B. acidophilus odontolyticus* which probably gains entrance to the localized area where caries starts by growing on food remnants.

Stomatitis.—General involvements of the mouth cavity will be only briefly listed here.

Aphthous Stomatitis.—Follicles or vesicles all over the mouth cavity. The vesicles rupture leaving small ulcers. Usually in children, associated with some general disease.

Ulcerative Stomatitis.—Fetid stomatitis or putrid sore mouth occurs in children after the first dentition. Gums, tongue, lips, cheeks, and pharynx are involved by the ulcers. A variety is seen in nursing mothers. Herpetie or pemphigoid stomatitis is a variety.

Thrush.—Invasion of the mouth by *Oidium albicans*, due to uncleanness, poor food, and decaying remnants of food in the mouth. Usually begins in the tongue in the form of slightly raised, pearly white spots and extends to cheeks, lips, soft palate.

Noma.—Gangrenous stomatitis is seen in convalescence from acute fevers, especially measles, in children who are not cared for in a sanitary environment. The rapidly progressing gangrene, due to no specific organism, involves the gums and cheeks, causing sloughing. The mortality is high.

Agranulocytic angina is usually caused by the use of aminopyrine compounds taken for headache. Since 1932 when Kracke noted this, examples of the disease are rare. A marked leucopenia and neutropenia precede the angina. Ulcerations form with remarkable rapidity all over the nasopharynx, gums, lips, and buccal mucosa. A brawny induration of the neck may cause stenosis of the trachea. Multiple septic infarcts of the lung and ulceration of the digestive mucosa may ensue. (Cases resembling agranulocytic angina have followed the use of other drugs—sulfanilamide, cincophen, allonal, alurate, bismarsen, and amytal.)

Mercury Stomatitis.—The gums are swollen, red and sore, the tongue is swollen, there is ulceration of the mucosa of the mouth. The tip-off is, of course, the ptyalism with swollen salivary glands and metallic taste in the mouth.

Leucoplakia.—McCarthy states that leucoplakia buccalis is by far the most common oral mucous membrane lesion (a surprising statement according to my experience).

Thoma (op. cit.) divides it into grades I, II, III and IV. It is likely to invade first the tongue, but in diffuse oral leucoplakia the roof of the mouth, the gums, lips, and buccal mucosa are covered with the characteristic opaque

white, smooth, sometimes fissured or rugose layer of changed mucosa. In these cases the tongue and pharynx are likely to be spared. It runs an essentially chronic course, always potentially malignant.

Tongue

As in all diseases of the mouth cavity the internist will instinctively divide diseases of the tongue into those which are local, and those which are manifestations of general disease.

Local diseases of the tongue are leucoplakia, geographic tongue (glossitis areata migrans), and carcinoma. Chancre should be included here because it appears to be local, resembles carcinoma at times, and should always be remembered as a possibility. Tuberculous nodes, fissures, and ulcerations tend to remain local; they are very rare. Actinomyces occurs as a local lesion.

Leucoplakia of the tongue has exactly the same characteristics as leucoplakia of other parts of the mouth described above—that is, it appears as a gray or silverish opaque pellicle which looks like a membrane but is not, is essentially chronic, in the last stages begins to ulcerate and bleed, and is always potentially malignant.

Erythema migrans, geographic tongue, is an eruption “dotted, spotted, circinate, annular, aureate, kaleidoscopic in the variation of its transitory appearances.” (Butlin: *Diseases of the Tongue*. Edited by Spence and Cade, P. Blakiston's Son, 1931.) There is no known etiology.

Carcinoma of the Tongue.—Usually an ulcer, its appearance may range from the small fungiform or ulcerous circumscribed lesion with elevated borders in old, emaciated, anemic persons to extensive involvement with induration and invasion in a young, florid person.

Chancre has an incidence of about 5 per cent of all extragenital chancres. It occurs more often in Stokes' (op. cit.) experience as an inconspicuous, smooth, eroded plaque with induration best apparent on palpation, almost devoid of subjective symptoms, than as the ulcerative type of Fournier.

Hairy tongue is due to hypertrophy and brown pigmentation of the filiform papillae.

General bodily states reflected in the appearance of the tongue are anemia, deficiency diseases, general debility, sprue, and alcoholism.

In Addisonian anemia, the anemias of pregnancy, often secondary anemia, the tongue tends to atrophy with a beginning period of soreness and rawness and perhaps painful vesicular eruption. “Raw, red tongue, raw, red gut” according to Lewis (Practitioner 125: 749, Dec., 1930). Hunter (Lancet 1: 221, 296, 371, 1900) is credited with the most complete description of the tongue of pernicious anemia. He described the injection of the margins of the tongue and atrophy of the intervening mucosa.

Issacs, Sturgis and Smith (J. A. M. A. 91: 1687, 1928) and Oatway and Middleton (Arch. Int. Med. 49: No. 5, May, 1932) have suggested recording tongue prints on smoked paper, which brings out the changes brilliantly. These can be shellacked and kept as valuable permanent records.

With the improvement in Addisonian anemia effected by liver extract, the glossitic changes tend to regress and this regression is permanent. (Middleton: Clinical Study of the Atrophic Tongue, Ann. Int. Med. 6: No. 3, Sept., 1932—good bibliography.)

The tongue of chronic alcoholism is probably a part of alcoholic pellagra. It begins as a swollen, clean tongue showing indentations of the teeth at the margins, and goes on to a bright red sore tongue, often developing ulcerations if not interrupted by therapy. (Blankenhorn and Spies: Oral Complications of Chronic Alcoholism, J. A. M. A. 107: No. 9, Aug. 29, 1936.)

The strawberry tongue of scarlet fever is characteristic and diagnostic even before the eruption appears; it is intensely red, with exaggeration of the papillae.

The under side of the tongue is supposed to be the place where the most delicate signs of onset and last lingering remains of jaundice can be detected.

Under the tongue a cystic swelling known as *ranula* occurs, due to an obstruction of the ducts of the sublingual and rarely submaxillary glands.

Late syphilis may affect the tongue in a very destructive manner. "When the fates invented syphilis," writes Hertzler (Surgical Pathology of Mouth and Jaws), "they gave the medical profession a break by giving the tertiary lesion a kidney shape, no matter where located." This is probably more relatively than absolutely true, but I can testify that the phrase sticks in the memory and suggests things to the diagnostician, which is an extremely important part of the art.

Gumma may be diffuse, nonulcerative, or it may affect the middle or one side of the tongue and ulcerate thereafter, becoming the seat of pyogenic or Vincent's infection and causing great destruction. Or a superficial gumma may be the foundation for syphilitic leucoplakia.

Superficial sclerosing syphilitic glossitis ("Glattzunge," syphilitic macroglossia)—"A tongue over a considerable portion of whose surface the papillae have disappeared or whose outlines or surface are distorted or lobulated by smooth, cicatricial, contractile bands." (Stokes, *op. cit.*)

Fissured tongue with nodulo-induration is another manifestation. The fissures are on the sides of the tongue.

Stokes warns that *histologic examination of these lesions is likely to be returned with the diagnosis of tuberculosis. Serologic tests are of more weight.*

The Tonsils

The tonsils are on the outposts of the body, which explains why they are so much considered. If they were as inaccessible as the thymus, we would not hear so much about them.

All I know about the tonsils can be put into very small space. I have for the purpose of this paragraph read a dozen monographs and textbooks and find that they all duck the discussion of function. I believe the tonsils have a function, at least in infancy and early childhood, that of protection from bacterial invasion and immunity. Certain it is that the tonsils are normally very large in infancy and tend progressively to atrophy. If you can see the tonsils at all in adult life it must mean that they are infected and pathologic.

They are subject to acute lacunar infection and Vincent's ulcerative infection. When these leave a residue of infection in the crypts of the tonsils, removal should be considered.

Examination of the tonsils in an adult should be conducted very carefully. The patient should be seated, and the examiner should have a good light directed on the tonsils. With one hand he should use the tongue depressor and with the other, with a small, thin tongue depressor or probe, he should expose the tonsil by drawing aside the anterior pillar, and he should squeeze it and note whether pus or cheesy deposits can be expressed from the crypts. The cheesy deposits do not mean much, but the pus does.

Some idea of what the examiner must inquire about in deciding whether tonsils are diseased may be learned from operative statistics of what removal of the tonsils cures.

When careful analysis is made of the cause for removal of tonsils and the results of tonsil operations, the following results are found: (Fowler: *The Tonsils*):

Recurrent sore throats or attacks of tonsillitis are cured in about 95 per cent of cases.

Otitis media is relieved in about 50 per cent of cases.

Frequent colds were reduced in 90 per cent.

Mouth breathing—one year after operation 93 per cent were improved.

Enlarged cervical glands—reduction in 40 per cent of cases.

Inflammatory rheumatism—recurrence of attacks is prevented in about 10 per cent of cases.

Neuritis, rheumatism, and other signs of "focal infection are relieved in about 15 per cent of cases.

Kaiser (J. A. M. A. 78: No. 24, June 17, 1922) in a study of 5,000 school children found mouth breathing, frequent sore throat, frequent colds improved in about the same percentage as the above figures. He found ear troubles relieved in about 70 per cent. Frequent attacks of fever were reduced. The nutrition of the children was improved by tonsillectomy in about 30 per cent. "A serologic test (for syphilis) on all cases of chronic atypical tonsillitis," according to J. E. Moore (Management of Syphilis in General Practice, Ven. Dis. Inform. Supp., 1939) is a rule that will apply in mild chronic tonsillitis with cervical adenitis when no actual mucous patches are present.

Leucemia.—The tonsils share in many cases the general lymphatic enlargement of leucemia. Every pharyngologist on finding tonsillar enlargement in an obscure case should request a blood examination.

Diphtheria.—The membrane in typical cases begins on one tonsil and spreads to the opposite side (57 per cent of all diphtheria is confined to the surface of the tonsils). If antitoxin is given at once, the inflammation is always confined to the tonsils. Extension from the tonsils to the faucial pillars occurs next. It is usually on the posterior nasal and pharyngeal mucous membrane if on the fauces. When infection occurs in the nose first, it goes down the posterior wall of the uvula, and examination of this should always be made in suspected diphtheria. Nasopharyngeal diphtheria occurs in 25 per cent of all cases.

The typical diphtheritic membrane is white, gray, and grayish green or gangrenous. Soon after formation it begins to curl off the mucous membrane at the edges. Occasionally there is bleeding, especially if the membrane is scraped off the underlying mucosa (a procedure which is not recommended therapeutically).

Septic, or Streptococcic Sore Throat.—The tonsils or pharynx is affected by a fibrinopurulent exudate. Onset is usually by a chill followed by temperature of 102° to 105° F., with rapid pulse. The throat is red, beefy, edematous, with the uvula often very swollen. A white, grayish white, or yellow-white exudate is on the tonsils and pharynx. It can usually be wiped off, but may be too heavy. The diagnosis is made from diphtheria and Vincent's infection by finding a strain of Lancefield's Group A hemolytic streptococcus. Lymphadenitis may be an accompaniment. Epidemics are usually milk-borne.

The soft palate shares most of the diseases of the general buccal mucosa. Three special conditions need to be noted:

Paralysis after diphtheria occurs most often in the pharynx first and often exclusively there. The best sign is the regurgitation of food through the nose on attempted swallowing.

Retropharyngeal abscess (quinsy) is a painful and distressing complication of acute tonsillitis. The signs are great embarrassment of respiration and deglutition with swelling and edema of the palate.

Perforating ulcer of the soft palate is "the nearest approach to a pathognomonic sign of syphilis to be found on the soft palate." (Stokes, *op. cit.*) It may be small, inconspicuous, and painless. It is essentially a necrosing gumma. Vincent's organisms may produce a somewhat similar perforation. (Barker and Miller: J. A. M. A. 71: 793, Sept. 8, 1918.)

The nasopharynx should be examined only with an electric-lighted instrument under proper conditions. Palpation of the nasopharynx to locate adenoids carries the possibility of many errors, both of omission and commission. (See Hill: Diagnostic Pitfalls of the Nasopharynx, J. A. M. A. 115: No. 9, Aug. 31, 1940.)

The Salivary Glands

Swelling, pain, inflammation of the parotid.

Epidemic parotitis (mumps) is the commonest cause, by all odds. The invasion is by fever, accompanied by pain below the ear. The parotid gland is evidently swollen and palpable within forty-eight hours. One side is usually affected first, but bilateral involvement occurs in two-thirds of all cases within four or five days. Suppuration may occur, but does so very rarely. The submaxillary and sublingual glands share the inflammation in some cases: in rare instances they alone are involved. The lacrimal glands and tonsils may also be swollen. Complications are orchitis (15 to 30 per cent of all cases), encephalitis (5 to 10 per cent of all cases), and deafness from inflammatory disease of the labyrinth.

Acute nonspecific parotitis may occur as a complication of infectious fevers—typhoid, pneumonia, general sepsis—and is a serious sign for prognosis.

Postoperative parotitis is rare—1 out of 2,275 cases. The theories of causation are: (1) degeneration of the gland as a result of high fever, (2)

degeneration of the gland attributable to operative measures on the generative system, (3) toxemia, (4) infective emboli, (5) infection extending through the lymphatics, (6) ascending infection by way of Stenson's duct. The last is probably most frequently the mechanism. Support is given this theory by the condition of the mouth, the inflamed appearance of the orifice of Stenson's duct. It points a way to prophylaxis. The condition is serious, the mortality being about 50 per cent, but the underlying disease is largely contributory. The parotitis may be said to be a herald of serious conditions. Irradiation has been a successful method of treatment. (See Madding and Fricke: Secondary or Postoperative Parotitis, *Surgery* 11: 45, 1942.)

Posttraumatic parotitis is also an entity. About half the cases follow an injury or temporary derangement of the genital organs—passage of a sound, introduction of a pessary, menstruation, a blow on the testis.

Uveoparotitis is an inflammation of the parotid gland with iritis. The onset may be ushered in with symptoms of fever and malaise, but the time of appearance of the parotitis is variable—sometimes as long as several months. The parotid involvement is generally bilateral. The inflammation is confined within the capsule of the gland, the overlying skin being free. The other salivary glands are often simultaneously or subsequently involved. The parotid swelling usually lasts two to six months, sometimes a year or more. The cervical supraclavicular lymph nodes are involved.

The ocular signs consist of burning of the eyes, photophobia, blurred vision, and iridocyclitis. Other complications are facial paralysis and erythematous skin eruptions.

The disease is self-limited, ending in complete recovery in over 95 per cent of cases. Three deaths have been reported in the literature from miliary tuberculosis.

The disease is a clear-cut clinical entity, but its nature and etiology are obscure. When histologic sections of the parotid or lymph nodes are submitted to pathologists, they report tuberculosis, but the patients usually show a negative tuberculin reaction. Michelson (Uveoparotitis, *Arch. Dermat. and Syph.* 39: 339, 1939) argues that it is a sarcoid reaction, defining the disease as a generalized one which does not invade any one organ, but has a predilection for the skin, lymph nodes, glands, bones, and lungs.

Mickulicz's disease is a chronic, painless enlargement of the lacrimal and salivary glands, beginning in the lacrimal glands and perhaps limited to them, but usually gradually extending. The parotids, submaxillary, and sublingual glands are all likely to be involved. The swelling is hard, not tender, and is apparently noninflammatory. The secretions of the gland are not disturbed, and the general health is not impaired. There was no participation of the lymphatic system in any of Mickulicz's cases.

The disease is not an entity. It may occur as Mickulicz described it, in both a familial and an acquired form, with no etiologic factor discoverable. But also Mickulicz syndrome may occur in the course of lymphatic leukemia especially, and also tuberculosis, syphilis, lymphosarcoma, lead and iodide poisoning, and gout. Age incidence is from two years on up. Prognosis is

variable, dependent on cause, but according to Thursfield, "one to five years releases the patient" from discomfort, disfigurement, and danger. (Lehman: Mickulicz Disease, Internat. Clin. 3: 105, 1910.)

Sialolithiasis (stone in a salivary duct or in a gland).—The diagnosis is frequently missed, most frequently by the very groups which the patients naturally and instinctively consult—dentists and nose and throat specialists. I have snatched at least one patient a year from the tonsillectomist for the last twenty years.

Incidence of involvement is: submaxillary stones, 75 per cent; parotid, 20 per cent; sublingual, 5 per cent. Multiple stones are the rule in the submaxillary gland (in my experience, but Greeley says, "usually single"). They vary in size from that of a grain of sand on up. The largest reported weighed 236 grams, was $1\frac{3}{4}$ inches long, 1 inch wide, and half an inch thick. Intraglandular stones are round or irregular; duct stones, oblong or oval.

They seldom produce symptoms until obstruction occurs, except for disagreeable taste in the mouth, possibly pus issuing from the mouth of the duct.

When obstruction occurs, the symptoms are extremely characteristic. There is sudden swelling and pain in the gland on the sight, or attempted mastication, of food. The pain is severe, but subsides rapidly, depending on the completeness of the obstruction. A foul taste in the mouth, especially in the morning, is a symptom volunteered by the patient, especially if infection of the gland has occurred.

X-ray visualization of salivary stones is undependable, for it involves difficulties of posing the patient, and the experience and patience of the radiologist. A negative report is without significance. The final diagnostic test is probing the ducts and the elicitation of grating. Greeley: Sialolithiasis, J. A. M. A. 102: 2078, 1934.)

Tumors of the Salivary Glands.—See Neck, p. 268.

THE EYE

The physical examination of the eyes includes the following:

1. Eyelids—edema. Eyelashes.
2. Lacrimal glands.
3. Conjunctiva—discoloration, injection, hemorrhage, granuloma.
4. Movements of the external muscles—paralysis, nystagmus.
5. The orbit—exophthalmos, enophthalmus, glass eye.
6. The cornea—scarring, ulceration.
7. The iris—size of pupil, fixation or movement. Accommodation to reflexes.
8. Vision.
9. Ophthalmoscopic examination is not recommended as a routine (see p. 818).

The general internist is interested in the eye for two reasons: *first*, what he finds there may suggest the disease which is the underlying cause of the

patient's trouble; *second*, the oculist may send him a patient and ask him whether a routine examination will disclose the etiologic factor of the eye disorder.

Following is a fairly comprehensive list of the general diseases which may cause or present as eye disorders:

1. **Infections.**—*Scarlatina* and *measles* (conjunctivitis, rarely corneal ulceration, even more rarely ocular muscle palsy); *whooping cough* (conjunctival hemorrhage); *diphtheria* (membrane-conjunctivitis); *erysipelas* (eyelids involved in 80 per cent of cases, abscesses of eyelid as sequelae, conjunctivitis, corneal ulcer, orbital cellulitis, ocular palsy, sinus thrombosis by extension through ocular veins); *gonorrhea* (ophthalmia, iritis); *leprosy* (corneal leproma, iritis, conjunctivitis, extraocular palsy; 29 per cent of lepers are blind or nearly blind); *anthrax* (edema of the eyelids, conjunctivitis); *undulant fever*, *brucellosis* (extraocular muscles, corneal degeneration, keratitis, retinitis, optic nerve atrophy); *tularemia* (edema of the eyelids, conjunctival tularensis); *smallpox* (conjunctivitis, corneal ulcer, iritis, anterior staphyloma); *vaccina* (papule or pustule of the lid from contamination); *mumps* (dacryadenitis, extraocular muscle palsy, keratitis).

Syphilis.—Two per cent of all eye diseases are caused by syphilis. A distinguished syphilographer once said that if he had only one organ to examine for evidence of syphilis he would choose the eye.

Congenital syphilis produces fixed or unequal pupils, strabismus, ptosis, nystagmus, keratitis (or scars of former keratitis), vitreous haze, retinal changes (optic neuritis, optic atrophy, pigmentation). Green (Am. J. Dis. Child. 20: 29, 1920) examined one hundred syphilitic children and found eye disease in 79.

Acquired syphilis produces chancre of the eyelid, periostitis of the bones of the orbit, ocular muscle paralysis, Argyll-Robertson pupil, gumma of the eyelid, conjunctivitis, scleritis, acute metastatic syphilitic corneal abscess (Klein: Arch. Ophth. 14: 612, 1935), interstitial keratitis, iritis and iridocyclitis, gumma of the ciliary body, choroiditis, retinitis, optic neuritis, optic nerve atrophy.

Tuberculosis.—Conjunctivitis (lichen scrofulosus), phlyctenular conjunctivitis, interstitial keratitis, abscess of the posterior cornea, iritis and iridocyclitis, uveitis, choroiditis, uveoparotitis or Heerfordt's disease (Folger: Arch. Ophth. 15: 1098, 1936), chorioretinitis juxtapapillaris, or Jensen's disease (Abraham: Arch. Ophth. 8: 503, 1932), retinitis, vitreous hemorrhage, tuberculosis of the optic nerve tuberculous retinal periphlebitis (Goldstein and Wexler: Arch. Ophth. 3: 552, 1930).

Parasitic Diseases.—In *filariasis* the parasites often get into the retinal and conjunctival vessels. *Trichiniasis* produces edema of the eyelids frequently as a first manifestation: the conjunctivae are involved. *Malaria*, corneal ulceration, a peculiar condition of bluish gray stripes around the macula. (Goldfelder and Moldavskaja: Arch. Ophth. 17: 228, 1937.)

Focal Infection.—Teeth, tonsils, sinuses, prostate, Fallopian tubes, intestinal toxemia, frequently produce eye disease, such as functional amblyopia, conjunctivitis, corneal ulcer, iritis, choroiditis, intraocular hemorrhage.

2. Drug and Chemical Intoxications.—Toxic amblyopia is caused by tobacco, and partial amblyopia by ethyl alcoholic beverages. Other toxic eye conditions are caused by *methyl alcohol* and *arsenic* (optic nerve atrophy); *atropine* (visual hallucinations—chronic use); *carbon disulphide* (optic atrophy, photophobia and chromatophobia); *bromides* (phlyctenular conjunctivitis); *dinitrophenol* used for reduction of weight (cataract); *Lash-lure, eyelash dyes* (dermato-ophthalmitis, conjunctivitis, edema of the eyelids); *lead* (sclerosis and periarteritis, sometimes hemorrhages of the retinal vessels; optic nerve atrophy); *morphine* (contraction of the pupil); *quinine* (diminished vision, pale nerve head on ophthalmoscopic examination); *thallium* used as depilatory (optic nerve atrophy, conjunctivitis, blepharitis, ptosis, strabismus, mydriasis, and cataract).

3. Cardiovascular Diseases.—Embolism of the retinal artery occurs in *mitral stenosis*, with sudden blindness in one eye. *Arteriosclerosis* and *nephritis* affect chiefly the retinal vessels. (See p. 820.)

4. Metabolic Diseases.—*Diabetes* causes cataract and retinitis (see p. 820), and iritis. *Toxemias of pregnancy* (retinitis, detachment of the retina).

5. Blood Diseases.—*Pernicious anemia* (retinitis, pale optic nerve head, hemorrhage into anterior and posterior chamber). *Leucemia*: Goldbach (Arch. Ophth. 10: 808, 1933) found 55 per cent of patients with acute leucemia, 62 per cent of those with chronic lymphatic leucemia, and 60 per cent of those with myelogenous leucemia had eye changes (retinal changes, hemorrhage into the vitreous or aqueous humor). *Polycythemia* (cyanosis retinae). *Purpura* (hemorrhage).

6. Endocrine Disease.—Graves' disease (exophthalmos). *Pituitary* disease (bitemporal hemianopsia).

7. Avitaminosis.—Vitamin A (nightblindness, xerophthalmia). *Ariboflavinosis* (keratitis rosacea, seborrheic conjunctivitis, cataract, optic neuritis), Vitamin C (cataract).

8. Nervous System.—*Herpes zoster* (herpes ophthalmicus). *Tabes and taboparesis* (Argyll Robertson pupil, dilated pupil, optic nerve atrophy). *Multiple sclerosis* (sclerosis of the optic nerve primary in 15 per cent of all cases, secondary in 40 per cent) (Lillie: Am. J. Ophth. 17: 110, 1934, nystagmus). *Brain tumor* (choked disc, ocular nerve palsy, hemianopsia, limitation of visual fields). *Brain abscess* (choked disc [30 per cent of cases], hemianopsia). *Epidemic encephalitis* (oculomotor palsy).

Examination of the Eye

1. Eyelids and Eyelashes.—

Edema of the eyelids is associated with many local, especially inflammatory, diseases of the eyes. As for manifestation of general disease, the internist will think of trichiniasis, nephritis, myxedema, and angioneurotic edema: anthrax rarely. (See Beach: *Edema of the Eyelids*, J. A. M. A. 83: No. 17, July 5, 1924.)

Chancere of the eyelid is rare. Wile and Holman found 68 cases of extra-genital chancre among 841 cases of primary syphilis, but record none on the eyelid, and one on the forehead. Ravogli, however, records several cases, one caused by a bite, one from rubbing the eyelid with a dirty finger, one from a syphilitic "healer" who licked the eyes of those suffering from ophthalmia, and one in a physician into whose face a patient coughed while he was touching an ulcerated throat.

Secondary syphilis affects the eyelids: they almost invariably ulcerate.

Erysipelas (see p. 256).

Blepharitis—ulceration of the hair line, multiple abscesses and ulceration at the base of the lashes are due to cosmetics, "Lash-lure" and thallium as a depilatory.

Ariboflavinosis causes seborrheic dermatitis and fissures at the edge of the eyelids.

2. *Lacrimal Glands*.—Mikulicz's disease (see p. 254).

3. *Conjunctiva*.—The conjunctiva mirrors the general state of health. Jaundice, lack of luster and ulceration, or scars of ulceration should be noted.

Many of the infectious diseases—measles, especially—produce conjunctivitis as a part of the disease. Whooping cough may have conjunctival hemorrhage as a complication.

Gonorrheal ophthalmia neonatorum never occurs in enlightened communities any more. Secondary conjunctivitis from contamination in patients with urethritis or vaginitis may occur but is rare.

Tuberculosis may appear in the conjunctiva as either a primary or a secondary manifestation and presents a variety of manifestations. The primary lesion may be ulcerative, nodular, hypertrophied granulation tissue accompanied by edema of the lids, or polypoid. Lichen scrofulosus is a granuloma of the sclera. Phlyctenular tuberculous conjunctivitis occurs.

Herpes zoster of the ophthalmic branch often extends onto the conjunctiva.

Syphilis may produce a granular conjunctivitis resembling trachoma.

The clinical manifestations of *tularemia* were first described by an oculist, Dr. Ancil Martin, of Phoenix, Arizona, who wrote in 1907, "There have been in this locality several individuals who suffered from an infection from dressing and skinning rabbits. Three of these have had their primary lesion in or about the eye. Small abscesses formed on the lids and on the bulbar conjunctiva as well. In one case the cornea was involved, the preauricular gland as well as the anterior cervical and the submaxillary." It is primary in the conjunctiva in 1 per cent of cases. The typical lesion is the occurrence of small areas, varying in size from 1 to 5 mm., on the tarsal and palpebral conjunctiva. The lids have to be everted to see them. They may be granulomas at first, but rapidly break down and ulcerate. They have been described as "yellow polka dots on a piece of red calico." (Hurst: *Tr. Am. Acad. Ophth.*, 1938.) As in all forms of tularemia, local glandular involvement is present.

Xerophthalmia (vitamin A deficiency) usually appears after the night blindness in the form of Bitot's spots, which are triangular, resembling a dense

foam, and occurring in the region of the palpebral fissure. There is also irregular xerosis of the bulbar conjunctiva with loss of luster and wrinkling.

4. The External Motor Muscles of the Eye.—The examiner will test the movements of the external muscles by asking the patient to follow his moving finger, noting absence of synergistic action and permanent paralysis.

Ptosis should be noted (third nerve). *Ptosis* occurs in cerebral syphilis, *tabes dorsalis*, facial paralysis, cerebral tumor, neuroses, meningitis, encephalitis, myasthenia gravis, migraine, bulbar paralysis, and it may be congenital or simply due to weakness.

Sixth nerve (abducens) paralysis, when acquired and coming on in adult life is almost pathognomonic of syphilis. The long course of the sixth nerve through the skull exposes it to infiltration from meningeal exudates and gummata. *The fourth nerve* is often injured in skull fractures on account of its exposed position at the crest of the petrous portion of the temporal bone. A variety of lesions ranging from tumor, hemorrhage, or trauma may affect the *third nerve tract*.

Horner's syndrome consists of sinking of the eyeball, drooping of the upper lid, constriction of the pupil and vasomotor and sudorific changes in the skin of the face. It is usually caused by injury to the cervical sympathetic but has been reported in meningitis, encephalitis, polyneuritis, and mitral stenosis. (See Fulton: *Ann. Surg.* 18: 2025, April, 1929, and De Jong: *Arch. Neurol. & Psychiat.* 34: 734, Oct., 1935.)

Nystagmus is the rapid, rhythmic, uncontrolled movement or oscillation of the eyeball—either laterally, vertically, or rotary. It is usually lateral, but may be in any direction. Three forms are distinguished.

1. Ocular nystagmus accompanying anatomic or functional disturbances of the eye—e.g., *blindness*, *strabismus*.

2. Labyrinthine nystagmus due to irritative or destructive processes of the inner ear.

3. Central nystagmus caused by intracranial pathology, particularly cerebellar disease and multiple sclerosis (one of the Charcot triad) and syringomyelia.

The differential diagnosis of the cause of any puzzling case of nystagmus had best be left to the otologist and oculist.

5. The Orbit.—

Exophthalmos.—Bilateral exophthalmos usually means exophthalmic goiter, but Ruedemann (*Cleveland Clin. Quart.* 3: No. 3, July, 1936; 3: No. 4, Oct., 1936, and 3: No. 5, Nov., 1936) lists twenty different causes. Most of these, such as hemorrhage into the orbit or hydrocephalus, would be obvious to any examiner. Those which should be noted are leucemia, chloroma, trichinosis, Paget's disease, acromegaly, and cavernous sinus thrombosis. Nephritis causes exophthalmos fairly frequently and Hanes (*J. A. M. A.* 121: 1152, April 3, 1943) has described a special physical sign—the "nephritic stare."

The eponymic signs of exophthalmos do not seem to me to be of much importance, but I give them below in the words of the original description:

DALRYMPLE'S SIGN was the first described and it is the best because simplest to detect. It was originally described in print by White Cooper quoting Mr. Dalrymple (*Lancet*, May 26, 1849). In exophthalmos "some of the muscles may be in a relaxed and others in a morbidly excited condition, so the eyes are nearly denuded of the protection of the upper lid by a constant and powerful spasm of the *levator palpebralis superioris* which draws the lid so far upwards and backwards that much of the sclera above the cornea is visible."



Fig. 23.—Exophthalmos in toxic goiter.

VON GRAEFE'S SIGN.—"When we cause a healthy person to look up and down, the upper eyelid moves correspondingly. In Basedow's disease this motion is almost completely abolished. When the cornea is turned downward the upper eyelid does not follow." (1864.)

STELLWAG'S SIGN.—"Infrequency and incompleteness of the involuntary closure of the eyelids." (1869.)

MÖBIUS' SIGN.—"If the patient is asked to fix his vision on the examiner's finger, the eyes do not converge." (1883.)

JOFFROY'S SIGN.—"If a person looks up at the ceiling quickly, holding the head still, as the eyeballs roll upward, the eyebrows are raised and the forehead wrinkles. In exophthalmic goiter the eyebrows and forehead remain immobile." (1893.)

I agree with Claibourne (J. A. M. A. 75: 851, Sept. 25, 1920) that all the eponymic signs of exophthalmic goiter are basically due to the exophthalmos.

The mechanism of exophthalmos is unknown, but probably it is due to hypertonicity of the plain muscles of the orbit. (For full discussion see Friedgood: Am. J. M. Sc. 180: 836, Dec., 1930; also Ruedemann: Exophthalmos, Cleveland Clin. Quart. 3: Nos. 40, 41, 42, 43.)

Unilateral exophthalmos is due to retrobulbar tumor of the soft tissues, bony orbital tumor, or varicocele of the ophthalmic vein.

Pulsating unilateral exophthalmos is due to arteriovenous fistula between the internal carotid artery and the cavernous sinus. Most cases follow trauma, a few are congenital. The signs are exophthalmos pulsation, bruit, diplopia, headache, and miscellaneous visual disturbances. (Martin and Mabon: Pulsating Exophthalmos, J. A. M. A. 121: 330, Jan. 30, 1943.)

Chloroma, or "green cancer," is a pigmented tumor which causes exophthalmos. It is closely identified with the leucemias; it usually occurs in children, with high leucocyte count, lymphatic enlargement, and enlarged spleen. The outcome is invariably fatal. (See Biering: J. A. M. A. 59: No. 16, Oct. 12, 1912.)

Glass Eye.—Never pass over a glass eye without investigation of the history. Find out why the eye was removed. The point, of course, is that it might have been melanotic sarcoma which will explain obscure lung, liver, and other visceral changes.

Syphilis of the orbit is a late manifestation. It is a periostitis with secondary involvement of the bone. The onset is marked by pain, which is worse at night. Exophthalmos is an early sign. Paralysis of the extra-ocular muscles follows as well as ptosis and limitation of the movement of the orbit. Choked disc is not infrequent. Whenever a syphilitic patient shows a unilateral choked disc, previous orbital involvement must be considered. The prognosis, in spite of the apparent seriousness of the condition, is good, under iodide of potash and mercurial treatment. (See Kemp: Arch. Dermat. and Syph. 8: 165, 1923.)

6. The Cornea.—Tuberculosis and bromides produce a phlyctenular keratitis. Keratitis occurs in about 50 per cent of congenital syphilitics. Acquired syphilis rarely affects the cornea. Acute metastatic syphilitic corneal abscess, as described by Fuchs in 1915, is very rare; there is pain, photophobia, redness, lacrimation with yellowish and sharply defined infiltrates in the deeper layer of the cornea, separated from the limbus by clear or partially opaque areas. (Klein: Arch. Ophth. 14: 612, 1935.)

Corneal leproma appears as a tumor. It produces opacity and blindness, often rupture of the anterior chamber.

Malaria produces corneal ulcers.

Ariboflavinosis produces keratitis.

7. The Iris.—Acute iritis is manifested by pain, photophobia, redness of the conjunctiva at the corneal margin and lacrimation. Metastatic gonorrheal iritis is rare. Iritis occurs in acquired syphilis during the second stage. It is said that 50 per cent of inflammations of the iris are syphilitic in origin. It occurs in 4 per cent of cases during the secondary stage. Woods (Syphilis

of the Eye, Am. J. Syph. 27: No. 2, March, 1943) describes syphiloma of the ciliary body. Gumma of the ciliary body has been reported. *Tuberculosis* of the iris or uveal tract is always secondary to a lesion elsewhere. *Diabetic* iritis occurred in eleven out of 2,360 diabetic patients: it seems to be a complication of an intercurrent infection or other process.

So-called *rheumatic* iritis is admittedly a misnomer, but nobody knows anything better to call it. It may be due to focal infection, allergy or any one of a dozen causes.

Melanoma of the iris has been reported as a primary tumor.

Pupils.—Note whether the *pupils* are equal, whether one or both is fixed, whether they are regular (round) or notched, and whether they react to light and distance. The iris is sensitive to many general states in the body, and fixed pupils, unequal pupils or irregular pupils may point to an old iritis which may mean syphilis, rheumatism, focal infection, gout, diabetes, hyperthyroidism, enterogenous auto-intoxication, etc. (See Pepper: The Importance of the Routine Medical Examination as Illustrated by a Series of Cases of Obscure Diseases of the Eye, K. C. Southwest Clin. Soc. Bull., 1925.)

Menninger (J. Kansas State M. Soc. 26: 1926) noted the pupils in 1,000 routine examinations at Bellevue Hospital and found some change in 17.6 per cent, irregularity in 13 per cent, inequality in 7.5 per cent, sluggish reaction to light in 10.6 per cent, no reaction to light in 2.8 per cent. The causes were fracture in 21 cases, trauma of some kind in 14 cases, chest diseases, 21, digestive diseases, 26, infection, 17, hernia, 15, heart disease, 14, arthritis, 4, cerebral hemorrhage, 5, and systemic syphilis, 4 cases.

Unequal pupils are always pathologic. Despite some reports to the contrary this is a safe rule. Refractive error or an old iritis may produce it.

The innervation of the iris is very complex (see Searlett and Cobb: Tr. Am. Acad. Ophth., 1919). The oculomotor nerve contains the constricting fibers; from its nucleus in the pons, connections go to the cortex. Stimulation of it contracts the pupil; section dilates the pupil. The cervical sympathetic innervates the dilating fibers; the dilator tract proceeds from possibly a cortical center to a center in the medulla, and thence into the lateral columns of the cord as far as the first and second dorsal roots. They then pass through the rami communicantes to the superior cervical ganglia and thence through the gasserian ganglion and nasal branch of the ophthalmic nerve, penetrating the sclera near the optic nerve and are distributed to the ciliary muscle. Stimulation of this tract dilates the pupil; section of it contracts the pupil.

Irritation mydriasis may occur from: trauma or concussion, pressure from apical pleural adhesions (tuberculosis), syphilis, aneurysm or aortitis, cervical glands, tumor of the cervical cord, meningitis, early stages of paresis and tabes, toxemia (the wide, fixed pupils of uremia, eclampsia and epileptic convulsions. Paralytic mydriasis occurs in many cortical lesions, after trauma, glaucoma, and the use of mydriatic drugs (atropine, etc.).

Irritation myosis occurs in: all inflammations at the base of the brain (meningitis or traumatic), brain abscess, sinus disease, apoplexy, tabes, tumor

involving third nerve, beginning of hysteric or epileptic explosion, tobacco amblyopia, myotic drugs (morphine, etc.), iritis. Paralytic myosis occurs in bulbar palsy, multiple neuritis, pressure from goiter, aneurysm, cervical glands, syndrome of Bernard-Horner.

In coma the pupils should always be studied. Menninger (J. Nerv. & Ment. Dis. 65: 6, 1927) made a valuable study and gives the data shown in the accompanying tables:

ALCOHOLIC COMA

	PER CENT
Pupils unequal	13.0
Dilated	12.0
Contracted	43.0
Reaction to light	
Prompt	44.8
Sluggish	19.0
Fixed	36.0

DIABETIC COMA

	PER CENT
Unequal	0.0
Dilated	10.0
Contracted	30.0
Reaction to light	
Prompt	60.0
Fixed	20.0

UREMIC COMA

	PER CENT
Unequal	12.0
Dilated	0.0
Contracted	24.0
Reaction to light	
Prompt	0.0
Sluggish	60.0
Fixed	12.0

CEREBRAL HEMORRHAGE (AUTOPSED CASES)

	PER CENT
Inequality (The dilated pupil is usually on the side of the hemorrhage)	74.0
Reaction to light	
Prompt	0.0
Fixed	90.0

SKULL FRACTURE

	PER CENT
Inequality (81% dilatation on side of brain trauma)	37.8
Size	No uniformity in findings
Reaction to light	
Prompt	37.0
Sluggish	23.4
Fixed	41.4

Reaction to Light and Distance.—Light reaction of the iris is preferably performed in a dark room, or at least the eye beam of light is rather quickly flashed upon the retina. To observe the reaction to distance requires even more care and concentration on the part of the examiner.

Pupillary reactions indicate the functional integrity of the iris, or the sign marks of old inflammation, and also the condition of parts of the ocular nerve tracts.

The most famous sign associated with double accommodation is the pupil described by Douglas Argyll Robertson (Edinburgh M. J. 15: 487, Dec., 1869). He referred to certain cases of spinal disease where "although the retina is quite sensitive and the pupil contracts during the act of accommodation, yet the alternation in the amount of light admitted to the eye does not influence the size of the pupil." . . . He was unable to explain this paradox, nor has subsequent research clarified the situation to any considerable extent. (See Merritt and Moore: The Argyll Robertson Pupil, Arch. Neurol. and Psychiat. 30: 357, Aug., 1933.)

Significance.—"The Argyll Robertson pupil as near as can be in an imperfect world is an infallible sign of syphilis of the nervous system." (Adie: Brit. M. J. 2: 316, 1931.)

Kinnear Wilson, however, states that the Argyll Robertson pupil occurs infrequently in epidemic encephalitis, occasionally in disseminated sclerosis, and not infrequently in cerebral tumor in the region of the third ventricle. (J. Neurol. & Psychiat. 11: 1, May, 1921.)

Reporters of Argyll Robertson pupils in other diseases have not adhered strictly to the criteria for determination of the condition. Those criteria are:

1. The retina must be sensitive to light.
2. The pupils remain constant in size ("fixed pupils" owing to a break in the light reflex arc).
3. Pupils small, though not necessarily equal in size.

By strict definition the Argyll Robertson pupil is never larger than 2 mm. in diameter. But there is an occasional divergence from this rule. (See New England J. Med. 229: 628, Oct. 14, 1943.)

4. They dilate imperfectly on instillation of atropine.
5. They contract actively on convergence accommodation (focusing the eye for vision depends on a reflex from the cerebral cortex to the oculomotor nucleus. The lesion that produces the Argyll Robertson pupil does not affect this pathway).

These phenomena are due to injury somewhere along the light reflex pathway (retina to third nucleus to iris), and injury to the sympathetic pupillo-dilator fibers. A lesion around the aqueduct of Sylvius would affect both systems of fibers, and, according to Merritt and Moore, with the exception of a few cases of gliomatous invasion of this region "the only incontrovertible cases heretofore reported were associated with syphilis of the nervous system."

Paresis—General Paralysis of the Insane.—Pupillary changes occur in all but 6 per cent of cases of paresis. They may be of considerable variety. If

taboparesis is present, the Argyll Robertson pupil will be found. The typical pupils of paresis are, however, large, usually unequal, with rapid variation in the size of the two pupils with regard to each other and responding rapidly, sometimes paradoxically, to light. Joffroy found the following frequency of pupillary changes in paresis:

	PER CENT
Altered light reflexes	78.0
Pupillary inequality	68.0
Lost light reflex	52.0
Irregular pupils	39.0
Diminished accommodation reflex	17.0
Mydriasis	13.0

Adie's syndrome.—Pseudo-Argyll Robertson pupil may be mistaken for Argyll Robertson pupil. Adie described it as “a benign, symptomless disorder characterized by pupils which react on accommodation, but not to light, and by absent tendon reflexes. . . . The Argyll Robertson pupil reacts promptly and often excessively on convergence, and dilates again as soon as the effort to converge the visual axes is relaxed. In these cases the pupils show the so-called myotonic reactions: they do not respond to light: they contract very slowly through a wide range during a sustained effort to converge: often remain small long after the effort ends and when they dilate again do so slowly.”

Later investigators have found that the Adie pupil is large, does respond to light on prolonged stimulation and dilates in response to mydriatics; the Argyll Robertson pupil does this very little. There is also a negative Wassermann. No regular cause for Adie's syndrome is found. (See Adie: Pseudo-Argyll Robertson Pupils With Absent Tendon Reflexes, a Benign Disorder Simulating Tabes Dorsalis, *Brit. M. J.* 1: 928, 1931.)

8. Vision.—The simplest tests for vision and the visual fields suffice for routine. A question about visual acuity, asking the patient to tell where the second hand of his watch is, moving a pencil held upright into the field of vision from either side, give a satisfactory idea of the state of the patient's vision.

THE EAR

The external ear presents no lesions of interest to the general internist except the tophi of gout. They are present in about 50 per cent of cases in the third and fourth stages. They tend to occur on the helix. The crystals of sodium urate obtained when the tophus ulcerates or is deliberately opened, when laid out on a slide can be readily identified by the microscope. Sydenham's description was: “The effect of the deposit of concretions is to destroy the skin and cuticle. Then you have chalk-stones like crab's eyes, exposed to view and you may turn them out with a needle.”

Tests for Hearing.—In a routine examination the presence of deafness is evident during the taking of the history. To confirm it the distance at which a watch can be heard is sufficient for routine physical examination.

If deafness exists, the voice test of Wolf, and the vibrator tests for bone conduction may be done in a short time.

Wolf's voice test is designed to determine whether the individual is deaf to high-pitched or low-pitched sounds. High-pitched words are: six, seize, tease, message, shady. Low-pitched words are: horror, rural, moon, rude. Medium-pitched words are: table, Mary, baby. In conduction deafness the high-pitched words are heard better than the low-pitched ones. In nerve deafness to a certain, but not absolute degree, the low-pitched words are heard better. F sounds are not heard in nerve deafness.

The Rinné test is made by holding first the handle of a tuning fork to the mastoid process, until the tone is no longer heard, and then holding the vibrating forks in front of the external auditory meatus. Normally the sound will again be heard when the tuning fork is held at the external meatus, the length of time the tone is heard through air being double or treble that heard over bone. This is the "positive Rinné." It occurs also in nerve deafness, though in this condition both bone and air conduction are shortened. In pure conduction deafness, the bone conduction is relatively lengthened and the air conduction relatively shortened. When this proceeds to a point where bone conduction exceeds air conduction it is called a "negative Rinné." There are other details and elaborations of the Rinné, but they are for the specialists.

The Weber test consists of placing a tuning fork on a central position on the skull and closing one meatus with the finger. Normally the vibrations are heard better in the closed ear. In other words, it is heard better in that ear in which a conduction deafness has been produced. When the middle ear alone, including the Eustachian tube, is diseased the tuning fork is heard better in the affected ear; when the internal ear is affected it is heard better in the unaffected ear.

The *stethoscope* test is valuable for detecting *malinger*ing. A common stethoscope, having one earpiece or tube plugged, is placed in the suspect's ears, the open tube to the suspected ear, the closed one to the normal ear. The examiner now whispers in the bell of the stethoscope. Then the instrument is removed and the normal ear plugged and the same formula repeated. If the suspect says he cannot hear the second time, he is malingering, because the conditions are exactly the same.

THE NOSE

The external appearance of the nose seldom gives any valuable hints to the general diagnostician. The saddle nose is due to a gumma perforating the cartilaginous portion of the septum of the nose. It is most often encountered in hereditary syphilis. The onset of the deformity usually follows trauma. To inspect the inside of the nose with a nasal speculum is not necessary for a routine examination and is best left to the specialist anyway. A few inquiries as to chronic discharge, face ache, etc., should be enough of a hint. Sinus infection never, in my experience, causes focal infection, but it may lead to chronic infection—bronchiectasis or asthma—of the lower respiratory tract.

PHYSICAL EXAMINATION OF THE NECK

Inspection and palpation are the means of physical diagnosis regularly employed to examine the neck for: pulsations, enlargements, paralysis, spasm or rigidity of the muscles.

Auscultation may reveal a *bruit* over the thyroid or transmitted to the carotids from the heart, but such bruits are of no special significance.

Pulsations of the carotid arteries are very marked in aortic regurgitation (p. 313). The very marked dislocation of the carotids in aortic regurgitation may be simulated by the pulsations of the carotids in hypertension (see p. 313) and sometimes in hyperthyroidism.

Venous pulsations in the neck seem to me to have little significance, unless they indicate a true arteriovenous shunt. Venous pulsations otherwise are simply transmissions of aortic pulsations. Prominent engorged neck veins indicate mediastinal or descending vena cava obstruction.

Aneurysm of the subclavian artery presents as a pulsatile swelling above the clavicle. The diagnosis is not often confusing. In the early stage referred pain may be called muscular rheumatism or bursitis. Goiter, substernal goiter, Hodgkin's disease occasionally are considered. (See Stokes: *Modern Clinical Syphilology*, p. 1081.)

Aneurysm of the innominate artery usually presents in the neck above the right clavicle, although the x-ray film will show a shadow in the chest and some of the early symptoms (cough, paroxysmal dyspnea from pressure on the trachea, substernal pain from erosion) which point to the chest often precede its appearance in the neck. In general, for an aneurysm it is painless. The x-ray shadow extends from the transverse aorta upward, in advanced cases well above the clavicle. Diagnosis is seldom in doubt, but dermoid cyst and substernal goiter may present differential puzzles. (Parks: *Aneurysm of the Innominate Artery*, Arch. Int. Med. 61: 848, June, 1938; Warfield: *Roentgen Diagnosis of Aneurysm of the Innominate Artery*, Am. J. Roentgenol. 33: 350, March, 1935.)

Aneurysm of the common carotid artery presents as a pulsatile tumor under the sternomastoid muscle.

There is an ampulla of the artery just before it bifurcates at the wall; it is thinner at this point, which is the site of election for aneurysm. A systolic murmur is usually heard over the sac. There is a weakening absence or irregularity of the temporal pulse. The cerebral blood supply may be deranged, leading to headaches, vertigo, insomnia, and temporary paralysis. Pressure symptoms in the recurrent laryngeal nerve leading to hoarseness have been described.

Classification of Swellings in the Neck

I. In the skin:

- Keloid
- Actinomycosis
- Carbuncle

- Furuncle
 - Anthrax
 - Sebaceous cyst
 - 2. Salivary glands:
 - Mumps
 - Submaxillary enlargement due to stone in the duct
 - Mixed tumors of the parotid, submaxillary, and sublingual glands
 - Carcinoma of the parotid
 - Cysts and adenoma of the parotid, submaxillary, and sublingual glands
 - 3. Lymph nodes:
 - Infections
 - Nonspecific—tonsils, teeth, etc.
 - Tuberculosis
 - Syphilis
 - German measles
 - Infectious mononucleosis
 - Hodgkin's disease
 - Tumors
 - Metastatic from lip, tongue, etc.
 - Lymphosarcoma
 - Lymphoepithelioma
 - Benign tumors
 - Lymphatic leucemia
 - 4. Enlargement of the thyroid gland
 - 5. Enlargement of the parathyroid glands
 - 6. Enlargement of the carotid body
 - 7. Blood vessels:
 - Thrombosis of the jugular vein
 - 8. Miscellaneous:
 - Cervical rib
 - Branchial cyst
 - 9. Infections:
 - Ludwig's angina
 - Abscess of vertebrae
- (Not all of these need comment.)

Skin.—

Anthrax.—Malignant pustule affects the skin of the neck next in frequency to that of the hands. Hide porters carry the skins on their backs, and they rub the skin of the neck. When a shaving brush is the infective agent, of course, the neck is the elected site. The inflammatory process passes rapidly from reddened itching skin to a papule which breaks down with coagulation necrosis in the center. At its height the malignant pustule (an unfortunate term, as pus rarely if ever occurs) prevents the appearance of purplish or dark red eschar pushing through the opening in the skin, surrounded by a dense hard edema studded with small vesicles. Meningitis and generalized anthrax may supervene.

Actinomyces usually enters by way of the mouth, infiltrates the submaxillary region, and reaches the surface under the jaw. It ulcerates its way through the skin and through the skin opening the red granuloma can be seen at the base surrounded by purplish, livid skin. The fungus is taken in with



Branchial cyst



Hodgkin's disease



Lymphoblastoma



Cervical gland enlargement
due to syphilis



Cervical gland enlargement
due to tuberculosis



Tumor of
carotid body



Cervical gland enlargement
due to tonsillitis



Metastatic cancer
of cervical glands

food and lodges around the teeth. In my experience infection occurs as a result of chewing a straw, which makes a penetrating wound in the floor of the mouth.

The descriptions of anthrax and actinomycosis are copied from textbook to textbook in stereotyped fashion, but in both cases, "Once seen, never forgotten."

Actinomycosis starting in the neck or jaw is likely to metastasize to the lung and chest wall, vertebrae, abdomen, or central nervous system—brain, meninges, or spinal cord. (Snoke: *Am. J. M. Sc.* 175: 69, 1928.)

Salivary Glands.—A neighbor of mine brought her little boy to me one evening in some doubt and distress because she could not entirely accept the diagnosis of a pediatric practitioner that the swelling under the jaw was due to a spider bite. He had a well-developed case of mumps so the necessity of mentioning this diagnosis is not futile. The submaxillary and sublingual glands may be affected alone without parotid involvement.

One of the common conditions most frequently misunderstood and misdiagnosed is stone in the salivary duct. I have seen any number of these called tonsillitis, mumps, abscess, and once when an incision was made in the cheek under the impression that the swelling was an abscess, a salivary fistula formed with tragic results. The submaxillary is the gland most often affected, then the parotid. The onset is sudden, with complete or partial obstruction of the duct. Discomfort becomes acute when something is taken in the mouth, for then the gland swells suddenly so that it is readily palpable and is exquisitely tender and painful. My cases have all been in young adults. The stones are often so sandy as not to show on an x-ray film, but sometimes quite large calcium stones occur and an x-ray is always advisable. Probing for the stone is easy and has diagnostic and therapeutic results. The diagnosis is not difficult, provided one keeps the possibility in mind.

Parotitis may occur as a complication of any general infection—most frequently general sepsis.

Tumors of the Salivary Glands.—The commonest are the so-called "mixed tumors." The parotid is most often affected but the submaxillary and sublingual may be. Hertzler (*Surgical Pathology of Diseases of the Neck*, J. B. Lippincott, 1937) has a picture of a mixed tumor of the sublingual gland alone. The cellular elements in the tumors are really mixed, including often cartilage, myxomatous tissue, epithelial and endothelial areas. I stand with Hertzler who wrote, "The variegated structure of these tumors inspires symphonic flights on the part of the histologist but it is meaningless to the surgeon and I suspect to the laboratory man himself. The term 'mixed tumor' is all inclusive."

Important to remember is that the clinical course is very slow and metastases are very rare. They are far from malignant in the ordinary sense. It is rare for the patient to present himself to the diagnostician before a period of two or three years from the onset—from the time he noticed a swelling. Hertzler had a patient whose tumor was forty years old. The typical parotid tumor is a hard, ovoid or lobulated tumor situated in front of and behind the

ear. These tumors invariably occur in the lower half of the gland in distinction to the adenomata and malignancies which occur in the upper half. In the course of time they become diffuse in the tissues. The submaxillary and sublingual tumors, according to Hertzler's experience, never invade the surrounding tissue. "No other tumors so well repay operative work: recurrences may be repeatedly operated on and finally cured."

Other tumors of the salivary glands are adenoma, cyst, carcinoma and malignant mixed tumors.

Lymph Nodes.—The great chain of neck lymph nodes* begins in, around, and under the parotid gland and extends down along the course of the external jugular vein and when infected, push up at the side of the sternomastoid muscle. The second great chain consists of the submental and submaxillary nodes. But closely associated are the occipital and mastoid nodes. A single mastoid node is particularly likely to be enlarged in German measles.

Since they drain the whole head, including the often infected mouth, pharynx, nose, tonsils, teeth and ears, the commonest enlargement of these lymphatic nodes is the nonspecific one from these causes. Location of the initial infection is usually sufficient to clinch the diagnosis. Metastatic enlargement from lip, tongue, and other head cancers is the common cause of their enlargement after the age of fifty. "Virchow's gland" is a single node behind the clavicular insertion of the sternomastoid muscle just above the clavicle: it indicates carcinoma of the stomach.

Tuberculous adenitis is a rare disease in this country since the use of pasteurized milk and/or the elimination of tuberculosis in dairy cattle. The typical case occurs in children or adolescents, involves the deep cervical or submaxillary nodes, progresses to characteristic fusion of the glands and adhesions to surrounding tissues, and has a strong tendency to fistula formation. In adults it may be very puzzling and although the matting and fistula formation are still characteristic, it may appear as large, bossy, semifluctuating masses.

Syphilitic adenitis may closely imitate tuberculous adenitis, especially in the adult Negro. (See Colin: Masses in the Neck, Am. J. Syph. 2: 67, 1918.) In differential diagnosis the Wassermann test and biopsy will probably always need to be employed.

Hodgkin's Disease.—The cervical lymph nodes are affected first in over 75 per cent of all cases of Hodgkin's disease, usually in the upper posterior triangle. Young males around the ages of twenty to thirty are most often affected. In the early stages the constitutional reaction is slight. The progress is usually slow. Later enlargement of the spleen, fever, cachexia, wasting, and wide dissemination through the lymphatic system occur. Any painless lymph node swelling, single or multiple, anywhere in the body, unless readily explained, should suggest Hodgkin's disease. The mediastinal primary involvement and skin lesions are discussed elsewhere. (See p. 430 and p. 193.) In differential diagnosis lymphatic leucemia and lymphosarcoma are always considered. The blood picture usually settles lymphatic leucemia. Since the

*By the way, they are not glands. They do not secrete anything. They are nodes.

normal final termination of Hodgkin's sooner or later is in the mediastinum, an x-ray study may be helpful. Some surgeons object to biopsy, but the damage can hardly be of much consequence. No other tumor or granuloma responds so quickly to x-ray therapy.

Lymphosarcoma is, according to Hertzler, "appallingly common, being second only to Hodgkin's disease among the serious primary diseases of the neck." Naturally mistaken for Hodgkin's disease, they, however, run different courses: Hodgkin's affects successive groups of nodes only, while lymphosarcoma spreads by extension and metastases. Lymphosarcoma tends to affect those in middle age and to run a more rapid course. The first swelling is generally in the upper part of the neck behind the sternomastoid. They seldom attach themselves to the skin, though fixation to other surrounding structures is common. They invade the mediastinum.



Fig. 25.—Hodgkin's disease.

Lympho-epithelioma, or endothelioma, is another malignant lymphatic tumor that has quite characteristic clinical features. The neck manifestations are usually preceded by the formation of a tumor in the pharynx or nasopharynx, commonly near the fossa of Rosenmüller, although this is not often discovered before the neck tumor presents. In the neck the tumor presents at the angle of the jaw. It is painful, fixed, and dense. "Location and density are all but pathognomonic." (Hertzler.) Other nodes may become involved, although the disease strongly tends to remain unilateral.

Benign tumors of the neck include lipoma, myxoma, dermoid atheromatous cyst (wen), chondroma, hemangioma, and lymphangioma. Lipoma may occur anywhere. One of Hertzler's cases was mistaken for a goiter. The

submental region is a favorite place for lipoma and dermoid. Chondroma arises from the hyoid or gill cleft, etc.

Hygroma or *lymphangioma* is found in infancy and childhood. If discovered late, its beginning can usually be traced to infancy. It feels, from external palpation, as if it was circumscribed, though operation seldom finds it so. They respond poorly, even badly, to irradiation.

The Thyroid Gland.—Very slight enlargements of the thyroid gland can be readily seen and felt. But with proper technique even the normal gland can be palpated and outlined. Do not stand in front of the patient and grab the neck as if you were going to strangle him. Stand behind the patient and instruct him to lower the chin so as to relax the sternomastoids. Then with your forefingers gently feel as you press the gland against the flat of the thyroid cartilage. Lahey (*J. A. M. A.* 86: 813, 1926) recommends a method in which the physician faces the patient and encircles the neck with both hands, thumbs anterior. Press the trachea toward the side to be palpated with one thumb and feel the gland under the sternomastoid with the other thumb.

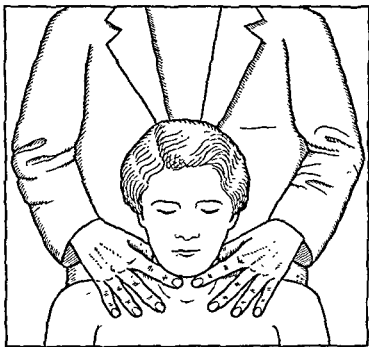


Fig. 26.—Palpation of the thyroid.

There are few pitfalls in identifying the thyroid. Even the commonest, a substernal thyroid with no gland palpable in the neck, is very rare. Even more rarely a tumor, as Hertlzer's lipoma case, or a dermoid occupies the site of the thyroid.

After determining that the thyroid is enlarged, it is necessary for the practitioner to determine what sort of an enlargement it is and how much

damage it is doing. The American Society for the Study of Goiter has accepted the following classification:

1. *Nontoxic Diffuse Goiter* is found mostly in childhood and adolescence. It is a soft, diffuse enlargement, representing a disturbance of physiologic function, lack of iodine in the food, menstrual, and endocrine disturbances.

2. *Nontoxic Nodular Goiter*.—This includes colloid goiter. Most of these are made up of lobulations which the diagnostician should be able to feel. They occur mostly in adult life but can occur in late childhood. After being located and classified, the diagnostician's duty is to determine toxicity. The basal metabolism should be determined, but Hertzler (*Diseases of the Thyroid Gland*, Paul B. Hoeber, Inc., 1941) insists and I think rightly that evidence of cardiac disturbance is more important.

3. *Toxic Nodular Goiter*.—This is perhaps only a development of the nontoxic nodular goiter, as it is possibly a development of the diffuse, nontoxic goiter. Under the older nomenclature these were called toxic adenoma. An evaluation of the amount of damage that is being done is often difficult in the borderline cases. A woman who has developed a goiter is naturally apprehensive and nervous, which causes tremor and tachycardia. A period of observation is often indicated, but not too long, as these goiters do not respond to medical management, and if left alone they may cause crippling cardiac damage.

4. *Toxic Diffuse Goiter* (exophthalmic goiter, Parry's, Graves', or Basedow's disease).—Few diseases are more readily recognized. It runs a typical and specific clinical course, with a definite beginning. In about 10 per cent of cases the gland is not notably enlarged. The symptoms are fatigue, increased appetite, palpitation, sense of heat in the skin, and usually weight loss. Exophthalmos is usually present. With it go the array of eye signs (see p. 260). Exophthalmos occurs occasionally in the toxic nodular goiter of late childhood. Tachycardia and tremor of the hands are quite constant. The presence of any three of the four cardinal signs—goiter, exophthalmos, tachycardia, tremor—is enough to decide a diagnosis. The basal metabolic rate is always high. I would not make a diagnosis until it was 40 plus or over. It may reach 125 plus. The only differential diagnosis that need be considered is a neurosis with tremor and tachycardia, and perhaps some thyroid enlargement. But the B. M. R. should settle these.

Fetal Adenoma.—A fetal adenoma of the thyroid is a true adenoma, about as near a thing to an embryonic rest as one will find in pathology. It lies inside the gland in its own capsule and may be palpated in children. It runs a very slow course, with sporadic or progressive increase as the case may be, and with a strong tendency ultimately to become malignant. It is usually single, though it may be multiple. In itself it does not produce symptoms of toxicity.

Atrophy of the Thyroid.—Both the classical syndromes of hypothyroidism, cretinism and myxedema, may develop on colloid or nodular goiters, but usually there is atrophy. In cretinism this may mean congenital absence of the gland. The diagnosis rests on the constitutional state rather than on the condition of the gland.

Parathyroid Glands.—(See p. 218.)

Carotid Body.—Tumor of the carotid is rare. All reported cases seem to be of the same kind. It is slow in growing and potentially malignant. It is easily removed in the beginning, but tends to invade the carotid vessels and, according to Hertzler, about the time the patient wants it removed, it is inoperable. The diagnostic points are that the tumor arises in the bifurcation of the carotid vessels about on the level of the upper border of the thyroid cartilage; it is ovoid in shape, smooth, not lobulated and is movable horizontally but not vertically. There may be nonexpansile pulsation, a bruit, and thrill. It may cause bulging of the wall of the pharynx and contraction of the pupils.

Cervical rib must be remembered by the diagnostician, though the manifestations are likely to be in the arms. (See p. 483.)

Branchiogenic Cysts, Branchiogenic Carcinoma, Thyroglossal Cysts.—The vestigial remains of the first cleft begin at the tubercle of the ear and continue down along the line of the jaw, terminating in the midline above the larynx. The second cleft arises in the region of the upper part of the sternomastoid and ends in the hyoid bone. The third and fourth clefts are in the region of the lower part of the sternomastoid just above the clavicle. Cysts arising from these structures may occur at any age from nine months to seventy years. Most frequently they occur between the ages of twenty and forty. They have a slow, painless growth, the skin moving freely over them. Sometimes they rupture, leaving a persistent sinus or fistula. Sometimes the contents of the cyst become infected as from a tonsillitis.

Carcinoma arising from the branchial clefts must be remembered. The tumor arises behind and below the angle of the jaw, is painful, and grows rapidly.

Thyroglossal Cyst.—Persistent thyroglossal duct may become cystic, forming a swelling in the midline somewhere between the isthmus of the thyroid gland and the base of the tongue.

Ludwig's angina is a diffuse infection of the tissues of the neck, following an infection of the mouth, although the initial focus may not be found. No description can improve on the original by Wilhelm Friedrich von Ludwig (*Medicinisches Correspondenz-Blatt des württembergischen ärztlichen Vereins* 6: 21, 1836).

"After a series of prodromal symptoms . . . there develops a firm swelling . . . usually in the cellular tissue surrounding the submaxillary gland. This . . . swelling spreads around the neck under the jaw . . . with marked lateral bulging. . . . The tongue lies on a floor of . . . indurated bright-red tissue, which feels like a hard, calloused ring along the inner border of the jaw inside the mouth. . . . Ability to open the mouth is restricted and painful . . . speech is difficult . . . thick and gurgling. . . . The skin, . . . in the early stages at least, is very slightly reddened if at all and is normal in texture; . . . later, soft red spots may appear . . . but no pus is ever formed. . . . The symptoms of the subsequent rapid course are those of a putrid-typhoid process, and in four to five days, the tenth to twelfth from the onset of the illness, coma develops and death occurs with indications of respiratory paralysis."

Muscles of the Neck

Whenever a serous membrane is inflamed, the muscles supporting and protecting it become rigid and limit motion. The meninges are no exception, and with meningitis, rigidity of the muscles of the neck and spine ensues. The patient lies with the head thrown back, and attempts to move it forward are resisted by muscle spasm strong in proportion to the severity of the meningeal irritation. In tuberculous meningitis the patient may be in opisthotonos with the legs drawn up in flexion. Kernig's sign of meningitis was described as follows (Berliner klin. Wchnsch. 21: 829, 1884):

"Extension of the patient's leg at the knee is only possible to an angle of 135 degrees, or if the phenomenon is marked, only to a right angle. . . . Further, with the patient in the dorsal position this contracture appears when the extended leg is brought to a right angle with the trunk. In normal patients no similar contracture is seen with the same degree of flexion of the trunk."

Torticollis when organic is a rigid contracture, fixed, permanent and indurated, of one sternomastoid muscle. Orthopedists distinguish two classes: the acquired, due to infiltration from infected cervical lymph nodes, and congenital, probably due to hemorrhage into the muscle as a birth trauma. Aside from the effect on the patient's psychology, it has no medical or diagnostic significance; the patient should be turned over to the orthopedic surgeon for plastic reconstruction.

Mental torticollis must always be considered by the diagnostician confronted with torticollis. It is a kind of chronic tic: the spasm disappears during sleep. Otherwise it may resemble torticollis. They are most difficult patients to treat. (See Clark: *Mental Torticollis*, Med. Rec. 92: 48, 1917; and Fisher: *Torticollis: A Review*, Am. J. Orthop. Surg. 14: 669, 1916; and Whitman: *Congenital Torticollis*, Ann. Surg. 65: 772, 1917).

Myositis ossificans progressiva affects the neck muscles early in the disease. See description under extremities.

Phantom Tumors.—Spasms of muscles may imitate real tumors and constitute a diagnostic puzzle. Sir James Paget records a case of a woman, about sixty, who had had a tumor on or over her parotid body. This had been removed about eight years before he saw her, and in the operation the facial nerve was injured. The facial muscles were partially paralyzed and subject to twitchings. In the last year there had been a renewed superficial growth over the parotid body and an increase in the facial twitchings. But what alarmed the patient was the appearance of a tumor, as she thought, below the left clavicle. This was the clavicular portion of the pectoralis major, partially contracted and hard, and perhaps made irritable by the frequent twitchings of the platysma. All appearance of a tumor was spoiled by raising the arm above the head.

Chapter 7

CHEST, ABDOMEN AND BACK—EXTERNAL FEATURES

The routine diagnostician, in pursuing his laudable purpose of making the most complete physical examination in the most expeditious manner, should reserve time before he begins to assess the internal viscera of the chest and abdomen to survey the external features of the body. It is well to do this with the patient in the standing position. With the patient prone all evidence of a hernia, epigastric or umbilical especially, disappears. The contour of the chest, lines of habitus are blurred. The back, of course, cannot be examined at all save in the standing position.

Routine examination should be directed at the following structures in order:

1. The general contour, muscular atrophy, and mobility deformities of the chest, abdomen and back.
2. The ribs and sternum.
3. The axillae, particularly lymph nodes.
4. The breast.
5. The umbilicus.
6. The abdominal wall for herniae.
7. The groin.
8. Superficial veins or phlebectasia.
9. The spine.

1. General Contour

The contours of the chest, aside from those which are classified as habitus (see p. 177), are the *phthisic*, the *winged*, and the *barrel or emphysematous*.

The *phthisic* chest is generally described as a long, flat chest with prominent ribs and winged scapulae. The designation means little, because this type of chest is often seen in the absence of tuberculosis. As a matter of actual record, the average thoracic index (the thoracic index is the value determined by dividing the anteroposterior diameter of the chest at the nipples by the transverse diameter at the same level) of adult males with tuberculosis is 77 per cent as compared with a normal of 67 to 70 per cent; i.e., the average tuberculous chest is deeper than the average normal chest (Weisman: *Contour of Normal and Tuberculous Chests*, J. A. M. A. 89: 281, 1927, and *Arch. Int. Med.* 50: 907, 1932). The chest gradually flattens from neonatal to adult life: thoracic index should change from 106 per cent to 67 per cent in eighteen years.

The *alar or winged scapula chest* is also of little clinical significance. Graves, in a series of studies extending over many years (see *Methods of Recognizing Scapular Types in the Living*, *Arch. Int. Med.* 36: No. 1, July, 1925 for complete bibliography), endeavored to formulate a classification of

the morphological types of scapulae as a basis for determination of a number of biologic tendencies, ranging from bone growth to longevity, morbidity, and human adaptability in general. The scapular types are based largely on the vertebral border contour below the scapular spine, whether convex, straight, or concave. He called the last the scaphoid scapula and considered it associated with other anomalies in development (anatomic, physiologic, psychic, and psychoneurotic) and also as a stigma of congenital syphilis.

The *emphysematous* or barrel chest has a high thoracic index—i.e., great depth. It, like the others, does not necessarily mean emphysema, although long-continued emphysema or asthma is likely to produce it. The average thoracic index of such a group was 82.8 per cent.

The deformities of the chest are funnel breast, chicken breast, kyphnotic and kyphoscoliotic chest.

Funnel breast or *trichterbrust* is characterized by a depression of the lower end of the sternum. In most instances the deformity is noted at birth or in early childhood and is comparatively small; the causes of its development are obscure: rickets, obstruction to respiration due to adenoids, and trauma have been implicated. Edeiken and Wolferth (*The Heart in Funnel Chest*, *Am. J. M. Sc.* 184: 4, Oct., 1932) found cases of mild and moderate degrees common. Moderate or severe grades cause a displacement of the heart to the left and usually upward, and occasionally the heart is rotated. Seldom, however, does it cause any kind of cardiac incapacity. Carr (*The Cardiac Complications of Trichterbrust*, *Ann. Int. Med.* 6: No. 7, Jan., 1933) reports some cases of dyspnea and palpitation relieved by operation.

Chicken breast is bulging, with prominence of the sternum, and unless associated with spinal deformity, causes no symptoms.

Chest deformity due to scoliosis and kyphoscolioses, on the contrary, enforces a very grave burden on the thoracic viscera. Of course the more extreme the deformity, the graver the burden. Slight to moderate deformities are no more serious than funnel chest, but Chapman, Dill and Graybeil (*Pulmonocardiac Failure Resulting From Deformities of the Chest*, *Medicine* 18: 2, May, 1939) make the surprising statement that in severe deformities the average duration of life is only thirty years. The most frequent cause of death of the hunchbacked is pulmonocardiac failure. Edeiken (*The Effect of Spinal Deformities on the Heart*, *Am. J. M. Sc.* 186: 1, July, 1933) found that most patients with kyphoscoliosis of severe grade have right-sided disturbance of cardiac function. Their activities are nearly always restricted by dyspnea and often they are cyanotic. The size, shape, and position of the heart are markedly changed. The electrocardiogram, except for axis deviation, is usually normal. The progression of events, according to Chapman et al., leaves no doubt that the primary difficulty is the thoracic deformity. Vital capacity is gradually reduced. The mechanism of pulmonary exchange lacks efficiency and incomplete oxygenation of the blood may occur.

Mobility of the Chest.—The comparative size and expansion of the two sides should be noted. Pleurisy more notably than any other intrathoracic

disease limits the motion of the affected side. The only illustration of a physical sign which Laennec incorporated in this book was this one.

Litten's sign, if it is to be performed at all during the examination, may better be elicited at this stage. The original description (*Deutsche med. Wchnschr.* 18: 273, 1892; and *Verhandl. d. cong. f. innere Med.* 13: 309, 1895) is as follows:

"I have observed that it is possible to see the movements of the diaphragm . . . on the thorax in all healthy men. The phenomenon takes the form of a wave motion that, beginning on both sides at the height of the sixth intercostal space, travels downward with maximum inspiration in the form of a straight line or shallow furrow (which makes an acute angle with the ribs) over several intercostal spaces, at times as far as the costal margin. With expiration, it rises again over the same area."

"The patient to be studied is placed in a horizontal position . . . with his feet toward the window, while the examiner, standing three or four steps away with his back towards the window, observes him from an angle of about forty-five degrees. . . . We are convinced that in a dark room the phenomenon is visible only if a source of light is so placed that the beams strike the thorax from the direction of the feet at an acute angle with the thorax."

I have never found Litten's sign of the slightest value. The x-ray has entirely superseded its usefulness.

2. RIBS AND STERNUM

Abnormalities of the Ribs.—Steiner (*Radiology* 40: No. 2, Feb., 1943) made over 38,000 radiograms in a study of rib abnormalities: 59, or 0.15 per cent of the total were found to have rib abnormalities. Besides cervical and lumbar ribs which accounted for half the total, the anomalies consisted of bipartition, synostosis, "tile roof" formation, and rudimentary ribs.

Actinomycosis is of thoracic distribution in about 15 per cent of all cases. From the primary foci in the lungs or pleura, sinuses opening on the chest wall usually occur, often with destruction of one or more ribs.

Blastomycosis of the pulmonary form also may form sinuses through the chest wall.

Tietze's disease was first described in 1921. It consists of painful swellings of the costal cartilages near the costochondral junction, nonsuppurative and with little constitutional disturbance. The patients are adults from 28 to 50 years of age. One case, followed over a year, did not develop any suppuration. The course is variable, with fluctuations in the size and tenderness of the swellings. The overlying skin is normal and freely movable. One, two, or three cartilages have been involved. The swelling is sometimes of considerable size, extending to the axilla, or filling the intercostal space. Some infection usually precedes the growth in most of the reported cases. A biopsy in one case showed only normal cartilage (or chondroma); in another, fibrositis and giant cells. In some cases the swellings disappear spontaneously but not all. (Tietze: *Berl. klin. Wchnschr.* 58: 829, 1921; Gill, Jones and Pollak: *Brit. M. J.* Aug. 8, 1942.)



Aneurism of
ascending aorta



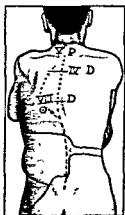
Aneurism of
ascending aorta



Aneurism of aorta
and innominate artery



Aneurism of
descending aorta



Aneurism of
abdominal aorta



Aneurism of
axillary artery

Fig. 27.—The chest. Aneurysm by inspection in various localities.

Sternum.—Pulsating sternum, or erosion of the sternum, is usually, but not always, due to aneurysm of the aorta. Aneurysm of the interval mammary artery, metastatic hypernephroma, malignant adenoma of the thyroid, Pancoast's tumor (intrathoracic tumor of confusing etiology and histology sometimes presenting *Horner's syndrome*), have been described as producing sternal pulsation: Lewis' case was a metastatic hypernephroma with a positive Wassermann, making a suggestion of aneurysm natural (Lewis: Brit. Heart J. 2: No. 4, Oct., 1940). (See also Crile: Pulsating Tumors of the Sternum, Ann. Surg. 103: 199, 1936; Malle: Ohio State M. J. 39: 346, April, 1943; Horsley: Pulsating Tumors of the Anterior Mediastinum, Surg., Gynec., and Obst. 75: 49, July, 1942.)

Solid nonpulsating tumors of the sternum include any form of benign or malignant bony tumor, sarcoma probably leading the list of primary growths and any metastatic tumor, hypernephroma and carcinoma of the thyroid being most frequent (Hedblom: Tumors of the Bony Chest Wall, Arch. Surg. 3: 56, 1921); Macey and Phalen (Surg., Gynec., and Obst. 76: 453, April, 1943) emphasize the importance of taking roentgenograms of the sternum in all cases of sternal pain.

Infections of the sternum include gumma, osteomyelitis and tuberculosis, in order of frequency. The sternum is a moderately favorite site for gumma. One-half of one per cent of all cases of osteomyelitis affect the sternum. Pain, excruciating with respiration, is the early sign. The infection can extend so that it destroys all the costal cartilages as in a case of Siler's (Surgery 12: 407, Sept., 1942). Tuberculosis involved the sternum in 1.1 per cent of a series of 1,134 cases of bone and joint tuberculosis. (Wasserburg: New England J. Med. 225: 445, Sept. 18, 1941.) Practically every case develops a draining sinus. The swellings are painless.

3. The Axilla

Swellings of the axilla almost exclusively originate in lymph nodes. *Furunculosis* is common in the axilla involving the nodes. *Tularemia* must be remembered even when there is an insignificant or healed sore on the finger. *Tuberculosis* and *syphilis* seldom involve the axillary nodes exclusively. *Infectious mononucleosis* frequently affects the axillary nodes, but as a part of cervical adenopathy and pharyngitis.

Hodgkin's disease and *leucemia* may locate in the axilla early and exclusive to other sites. Baldrige and Awe (Arch. Int. Med. 45: No. 2, Feb., 1930) observed 150 consecutive cases of lymphoma (under which name they included a number of lymph node growths) and found the axillary nodes involved 32 times in Hodgkin's, and 50 times in leucemic types. In two cases of Hodgkin's disease the axillary nodes were enlarged first, before any other bodily lymphadenopathy was observed. Burnam (J. A. M. A. 87: 1445, Oct. 30, 1926) found that Hodgkin's disease affected the axillary nodes in 58.3 per cent of cases, but never primarily in his series.

Lymphosarcoma, or malignant endothelioma, affected the axillary nodes 15 times in Baldrige-Awe's series, never primarily, while in Desjardin and Ford's

series (J. A. M. A. 81: 925, Sept. 15, 1923) lymphosarcoma affected the axilla in 50 per cent of all cases.

"The axilla is a deep well," writes Ker, in his text on infectious diseases. He refers to the exanthems and especially to the prodromal rashes which appear in the axilla and the interpretation of which allows the diagnostician to predict and anticipate the generalized rash, particularly of smallpox and chicken pox. By reason of its constantly damp and warm conditions skin eruptions in the axilla are likely to be particularly bright and vivid. The prodromal rash of smallpox, usually an erythema, may be generalized but is always brighter in the axilla than anywhere else and may be exclusively confined to the axilla.

4. The Breast

It is certainly the function of the internist to examine the breasts, although he usually seorns this part of his routine. Nor do many internists or even surgeons follow a logical and systematic routine in making a breast examination.

First, what are you looking for? What are the diseases of the breast? "It is easier," as Hertzler says, "for the surgeon to act like one who knows what he is talking about if he actually does know."

A. Developmental anomalies are multiple accessory breasts and unequal development of the two sides either at puberty or hyperplasia in adult life. In the last condition one breast may be much larger than the other, and malignant tumor is often diagnosed. Recognition is easy if the possibility is kept in mind, because the breast is soft and compressible with no evidence of the presence of a tumor.

B. *Inflammation of the mammary gland.*

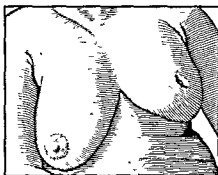
- a. Infantile mastitis is acute, usually nonsuppurative and mysterious.
- b. Puerperal mastitis, usually nonsuppurating but occasionally suppurative.
- c. Chronic infectious mastitis is often mistaken for malignancy, but a history of long duration is a clue to the benign nature of the condition. They often follow on an acute puerperal mastitis.
- d. Traumatic mastitis with fat necrosis. Any trauma, even the pressure of a corset, sufficient to injure fat tissue, is the cause. The mass produced by fat necrosis is surprisingly hard. The skin is not freely movable over it.
- e. Granulomata of the breast, tuberculosis, syphilis, and actinomycosis are rare, tuberculosis being the most common.

C. Chronic mastitis (interstitial and parenchymatous—whatever you wish to call it), cystic mastitis, diffuse fibroadenoma, involution cysts, Schimmelbusch's disease, interstitial metaplasia, parenchymatous hyperplasia are various names for the disease which gives the clinician the most trouble to differentiate from malignant tumors. It is not an inflammation nor a neoplasm, but probably an involution process which may go through various stages, hence the many names applied to it. It may present pain and nodular tumor. It is thus easily

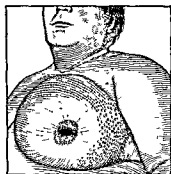
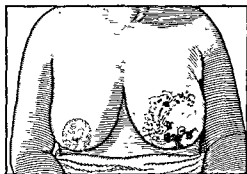
INSPECTION



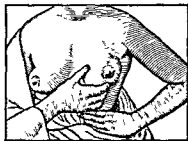
Level of the Nipples



Retraction of the Nipples

Quality of Skin.
'Peau D'orange'Quality of Skin.
Comparative Size of Breasts;
Excoriation of Skin and Nipple
due to Paget's Disease

PALPATION

Palpation of whole breast
with flat of hand and palmPalpation of each quadrant
between thumb and finger

between thumb and forefinger palpate each quadrant of the breast and palpate directly behind the nipple. Record the findings of both breasts. If there is a lump, note its movability or fixity to the skin or pectoral muscles. Palpate the axilla for axillary nodes.

Transillumination may be carried out in a dark room by placing an electric flashlight under the breast. Cysts and tumors can often be outlined in this way. X-ray examination also is used.

If a lump or diffuse invasion is found, can the clinician try to arrive at a diagnosis or should a piece of tissue always be removed for biopsy? I do not feel competent to answer this question. In most cases the decision will be taken out of the clinician's hands by the patient herself. Certainly the clinician should be able to decide whether he needs surgical advice or not. Hertzler believes the diagnosis should be made by gross pathology, but only with a wide open operation, as I understand him. It is the borderline group, he argues, in which the pathologist is not certain, that 100 per cent of cures are attained. "It is one of the smart facts in medicine that when an epithelial proliferation is cancer; it is easily recognized as such."

An almost equally difficult problem for the clinician occurs when the patient has subjective symptoms, but no physical signs. Fat women with large breasts and women after the menopause, especially childless women, often have discomfort in the breast. If the symptoms are present only at the time of menstruation, they lose their significance. "Family quarrels cause as many sore breasts as sore heads." Young ladies who go on petting parties often end up with aching breasts as well as aching hearts. And most potent of all is the discomfort that began when a relative or neighbor died of cancer of the breast.

Although the female breast is the one usually discussed, the male breast is also, though rarely, subject to tumors and mastitis.

The scar of a removed breast is probably of more significance to the general diagnostician than any condition of the breast in situ. He must get the fullest account, preferably from the surgeon responsible, of why it was removed. Extension of mammary tumors is, in the great majority of cases, by way of the lymphatics to the axillary, supraclavicular and more rarely, to the umbilical regional lymph nodes. The axillary nodes are divided into three groups—the anterior pectoral at the lower border of the axilla, beside the lower edge of the pectoralis major; second, the central group above the deep fascia, just beneath the axillary vessels and extending into the brachial; third, the subclavian, rather high above the axilla in the body of the pectoralis muscles.

Constitutional metastases are those: (1) within the cranial cavity and are likely to present the symptoms of any progressive intracranial tumor. The symptoms may begin so long after the breast removal that the latter has been forgotten, or at least lost sight of as the cause.

(2) Metastases within the thorax presenting a great variety of symptoms of bronchial irritation, lung, pleural or mediastinal involvement. "I have

seen," writes Hertzler, "the mediastinal involvement begin ten years after the breast operation, and progress slowly for another ten years."

(3) Metastases to the liver producing epigastric distress, enlarging liver, and jaundice. All of these conditions lead to embarrassing gall bladder drainages, exploratory laparotomies, intracranial operations, thoracotomies, pleural drainages, etc., if the history of mastectomy is not uncovered.

(4) Metastases to bones may occur before the breast cancer is even palpable, as well as after mastectomy. Any of the long bones may be involved and a spontaneous fracture the first indication. Frequent and most distressing on account of the pain produced by pressure on nerve roots are the metastases to the spine, which may occur from cervical region to sacrum.

(References: Hertzler: *Surgical Pathology of the Mammary Gland*, J. B. Lippincott Co., 1933. Every internist should be made by the American Board to read this vivid account by a master clinician. Bailey, Hamilton: *Physical Signs in Clinical Surgery*, William Wood and Co., 1930. Cheate and Cutler: *Tumors of the Breast*, J. B. Lippincott Co., Undated—circa 1940. Woolsey: *Late Recurrence After Radical Breast Operation*, *Ann. Surg.* 80: 892, Dec., 1924. Shows how the metastatic disease may come so long after the original breast condition as to seem a new disease.)

5. Examination of the Umbilicus

The umbilicus in the newborn is subject to hemorrhage, granulation tissue, and infection. After the period of those dangers is over, it is subject to the following abnormal conditions:

I. Developmental Anomalies.

A. *Omphalomesenteric duct*.

1. Patent with fecal fistula or discharge of clear nonfecal viscid fluid.
2. Not patent, but showing remnant covered with skin.

B. *Meckel's diverticulum* is attached to the umbilicus in about 25 per cent of cases. It may protrude as a hernia or it may cause intestinal obstruction from torsion, with pain centering in the umbilicus and retraction of the umbilicus.

II. *Umbilical Concretions*.—Occur most often between the ages of twenty and sixty. Cause considerable abdominal pain. May look like an acute inflammation of the abdomen. Discharge of concretion with blood and pus, followed by relief. The concretion forms on the basis of cheesy masses in the umbilicus. Usually can be felt in the umbilical depression, but sometimes at the side.

III. *Paget's Disease of the Umbilicus*.—Similar to Paget's disease of the nipple.

IV. Infections of the Umbilicus.

- A. *Syphilis*.—Both congenital and in the adult. In the adult it may form a tumor or an ulcer with a fetid discharge.
- B. *Tuberculosis*.—Granuloma formation. Acute abdominal pain with a discharge from umbilicus.

V. *Escape of Fluid From Umbilicus.*—The causes of this may be legion: leakage of an abdominal aneurysm, abscess of the liver, broad ligament, appendix, peritonitis, even escape of pleural fluid is given by Cullen.

VI. *Umbilical Tumors.*

A. *Primary.*—Angioma, myxoma, fibroma, papilloma, lipoma, dermoids, adenomyoma, carcinoma, sarcoma.

B. *Secondary.*—Can be from stomach, gall bladder, intestine, ovaries, uterus, or breast.

VII. *Umbilical Hernia.*—In the adult it occurs more often in women and more often in the obese. When incarcerated, it may be the cause of obscure abdominal symptoms.

VIII. *Urachus.*—Patent urachus may connect with the bladder and discharge urine or pus. Large and small urachal cysts occur and may present as abdominal tumors, usually close to the abdominal wall, midline, and in the region between the umbilicus and the symphysis.

IX. *Caput medusa* is an engorgement of veins at the umbilicus due to cirrhosis of the liver. It must be very rare.

Reference: Cullen, Thomas, Stephen: *Embryology, Anatomy and Diseases of the Umbilicus Together With Diseases of the Urachus*, W. B. Saunders Co., 1916.

6. *Hernia*

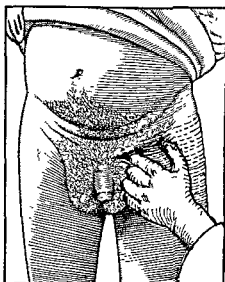
This is another examination, like that of the heart and spine, which the internist neglects, thinking that there is no problem involved, that anyone who has a hernia will know it and state so, and that no diagnostic problem is involved or that it is settled by the examination or discovery of a hernia. In all of these conclusions he is only partially justified. Dr. J. N. Hall of Denver long ago called our attention to the fact that epigastric hernia was the cause of much obscure dyspepsia: in the routine examination of draftees he found many cases that were totally unknown to the owner. I believe that hernias are contributory to much poor health from their effects on posture, visceral dragging, and especially emotional attitude.

The examination for hernia consists first of inspection. This also is contrary to the ingrained belief of the internist, who wants to stick his finger into the hernial ring first thing. With the patient exposed (and also straightened up because he will almost certainly be craning over to see what is going on—Bailey), and facing the examiner, inspection at normal respiration and on coughing will show hernial protrusions better than palpation. The epigastric, umbilical, inguinal, and femoral regions should be rapidly inspected in this way in order.

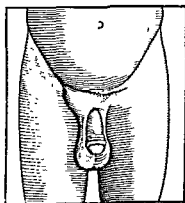
Epigastric hernia is through the linea alba between the xiphoid cartilage and the umbilicus, but commonly near the latter. They are usually small. "The patient complains of epigastric radiating pain or discomfort, particularly post-prandial, or after exertion. Nausea and vomiting are not infre-



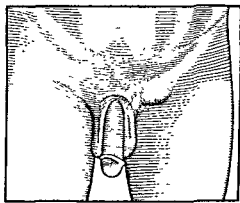
Impulse on Coughing



Palpation of
Inguinal Canal



Inguinal Hernia



Femoral Hernia

Fig. 29.—Examination of the groin for hernia.

quent and, in fact, out of all proportion to the actual size of the hernial protrusion." (Iason: *Hernia*, The Blakiston Company, 1941.)

Umbilical hernia occurs in infants and adults. In adults it is commonly an acquired defect in the linea alba, directly above the upper margin of the umbilicus. Obesity is the common predisposing cause. Diagnosis is made by inspection and palpation with the patient erect and then recumbent, in quiet respiration and on coughing. It is likely to cause more symptoms than any other hernia—varying degrees of nausea, cramps, flatus, belching, and constipation. Differential diagnosis is from (a) subperitoneal lipoma, (b) tumors of abdomen, (c) urachal cysts, (d) Meckel's diverticulum.

Diastasis of the recti occurs after pregnancy and with other abdominal tumors before and after removal, sometimes in elderly persons without known cause.

Lateral ventral hernia is through the linea semilunaris. Very rare.

Lumbar hernia is through Petit's triangle between the latissimus dorsi and the external oblique just above the crest of the ilium.

Scar hernia or incisional hernia should be looked for when laparotomy scars are present.

Inguinal hernia protrudes along the inguinal canal above Poupart's ligament or into the scrotum. Diagnosis is made by inspection and palpation with the little finger thrust up through the scrotal folds into the canal with the patient in the erect and then in the recumbent position, on quiet breathing and on coughing. It must be differentiated from (a) femoral hernia, (b) hydrocele, (c) maldescended testis, (d) lipoma of the spermatic cord, (e) fibroma of the inguinal canal, (f) enlarged inguinal glands.

Femoral hernia is a protrusion of abdominal or pelvic viscera or peritoneal fat under the inguinal ligament and through the femoral ring into the femoral canal, usually medial to the femoral vein. Diagnosis is made as in inguinal hernia, by inspection and palpation. In differentiating from inguinal hernia, the protrusion is below Poupart's ligament. Symptoms of uncomplicated hernia are few. Strangulation is ten times as frequent as in inguinal hernia and produces an acute abdomen. In a series of such cases Dunphy (J. A. M. A., 1940) found "the correct diagnosis was established prior to admission to the hospital in only 57 per cent of the cases. In many instances both patient and physician were unaware of the presence of a hernia. In others a long-recognized hernia was dismissed as a possible cause of the symptoms because there was no local tenderness or pain in the groin." Differential diagnosis must be made from (a) adenitis, (b) lipoma, (c) oblique inguinal hernia, (d) saphenous varix, (e) psoas abscess, (f) aneurysm of the femoral artery, (g) hydrocele of the femoral sac.

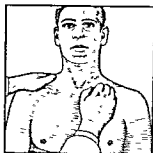
7. Groin—Lymph Node Enlargement

A single-sized bubo in a female may strongly indicate the presence of a chancre in the labial folds not immediately evident even on careful inspection. Chancre of the cervix metastasizes in the pelvic glands and can be felt, if at all, by rectum.

CERVICAL

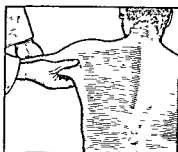


Sub-maxillary



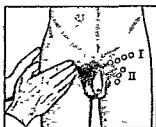
Supra-clavicular

AXILLARY

Mid-axillary and
Anterior Fold

Posterior Fold

INGUINAL



I - Above Poupart's Ligament

II - Below Poupart's Ligament

Fig. 30.—Palpation for superficial lymph nodes.

The lymphadenitis associated with genital chancre is one of the most characteristic signs of early syphilis and still in spite of modern laboratory methods of examination, of strong diagnostic value. Its course is slow and indolent; it is notably indurated with no tendency to break down. "It is," writes Stokes, "one of the most unvarying and trustworthy of the few remaining clinical guide posts to the recognition of the disease." The "satellite bubo" of Ricord, the single, or single bilateral bubo, is not so hard and fast a rule as he would have had his pupils believe: exceptions are very frequent. Stokes says that in his experience 30 to 40 per cent of primary lesions did not present clinical lymphadenopathy at the time the laboratory examination identified the chancre. But certainly the satellite bubo is of great diagnostic weight when present. The "bubo d'emblée" of which Ricord also wrote so much—the primary bubo which appears without visible or immediately discoverable chancre is also a valuable sign.

Primary tuberculosis in the inguinal lymph nodes is very rare.

Hodgkin's disease affected the inguinal lymph nodes primarily two times in 150 consecutive cases of lymphoma observed by Baldrige and Awe (op. cit.), lymphosarcoma two times, and lymphatic leucemia four times.

Granuloma inguinale is a chronic, ulcerative process involving the genitalia, the groin, and the perineum. It occurs almost exclusively in the Negro. The initial lesion is a papule which enlarges, ulcerates, and becomes vegetative with a tendency toward slow peripheral extension, healing with contrasting bands of scar tissue.

Lymphogranulomatosis inguinale is a contagious disease transmitted by intercourse and characterized by an ephemeral insignificant genital lesion, usually unobserved by the patient and followed in about two weeks by an indolent adenitis involving the inguinal and iliac lymph nodes. The glands are at first discrete, but gradually fuse and adhere to the overlying skin. They soften and produce multiple fistulas.

The inguinal lymphadenopathy of chaneroid may be unilateral or bilateral, is likely to be multiple, and may resolve or go on to suppuration.

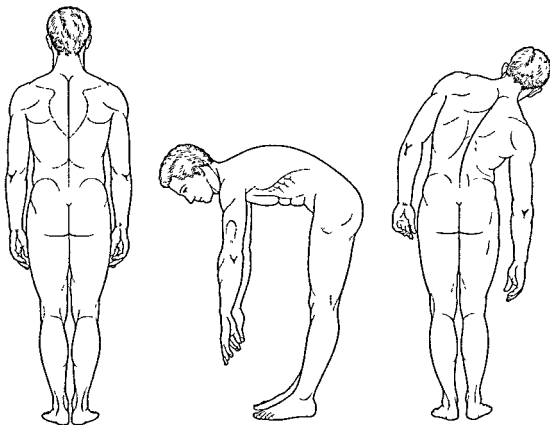
8. Phlebectasis

Dilatation of the cutaneous venules of the chest or abdomen may take many forms. The one to which the clinician is inclined to attach significance takes a distribution like a belt at about the level of the rib margins. They have been assigned to liver, heart, and lung disease. Morgan (Subcutaneous Phlebectasis of the Lower Thoracic and Upper Abdominal Regions, J. A. M. A. 74: No. 25, June 19, 1920) was inclined to regard them as the accompaniment of pathologic visceral changes though he was unable to formulate any definite significance for them. Burrett and Scherf (Am. J. M. Sc. 201: No. 3, March, 1941), on the contrary, state that they are found in healthy persons and that a study of 385 patients in which they occurred revealed no pulmonary, pleural, or cardiac disease. They increase with age. I have never found that they meant anything.

9. The Spine

Discomfort, disability, and deformity, according to Lewin, are the disturbances of the spine which concern the patient and physician about equally.

The classification of causes of backache, as given on p. 104, can very well be used as a mental memorandum for the diagnostician during the physical examination of the back.



In the erect position. Bending forward. Bending sideways

Fig. 31—Method of examination of the back by inspection.

"Incredible though it seems, there are physicians in practice today who do not hesitate to treat lumbar pain without stripping the patient so that the naked back can be examined. I have known a case of herpes zoster to be treated for 'rheumatism' (salicylates, alkalies, vegetable diet, etc.) simply because the vesicular eruption was unknown to the patient and had never been looked for by the physician.

"Osler mentions a case of aneurysm of the descending thoracic aorta, which presented as a pulsating tumor near the angle of the left scapula, quite undiagnosed through many weeks of treatment for lumbago and neuralgia. The attending physician had never examined the exposed back, presumably because the patient, being a male, wore clothes which opened in front and did not offer to remove them." (Cabot: *Differential diagnosis*, W. B. Saunders, 1911.)

There is probably no feature of the physical examination that the average internist carries out in as sloppy and uninformed manner as he does the examination of the spine. He seems to think that if there is something the matter with the spine the orthopedic surgeon should be consulted or that the orthopedic surgeon will eventually detect what is wrong. This is a completely confused decision because people with spinal disease do not always have spinal complaints and vice versa. Spinal disease may result in the complaint of abdominal pain or many forms of vague chronic invalidism not immediately suggesting the spine, and those who have backache may have nothing the matter with the back at all, but must be saved from all sorts of manipulation and quackery by the internist who knows a good back when he sees one.

Nor will it do to feel comfortably that you can turn these patients over to the radiologist. Some of the most important things to be learned about the spine—the way it functions for instance—are not revealed by the x-ray, but by physical examination.

The spine goes through developmental changes. In infancy it is extremely flexible and the normal curve of the spine of the infant sitting up is a gentle curve with the apex of the curve at about the sixth or seventh dorsal vertebra. By early adult life the normal curves are a slight lordosis of the cervical blending into the symmetrical kyphosis of the dorsal and giving place to the lordosis of the lumbar which merges into the kyphotic tilt of the sacrum. By this time it has lost much of its flexibility. The dorsal vertebrae hardly move on each other at all in any position, a necessity of the rib attachments and the requirements of protection and function of the chest.

With the patient standing flat on his heels and the physician watching from the side, if the patient bends over until the fingers are touching the toes, the normal spine makes a gentle, even curve, not sharply broken or flattened at any point. With the patient erect, heels together, the examiner standing directly behind him asks him to bend sideways until the finger tips are on a level with the knees; the normal spine bends sharply at the fourth lumbar level. Above that the spine bends in a gentle, regular curve from lumbar to cervical region.

Any filling defect or deviation from these normal curves will be regarded by the diagnostician as the most delicate indication of infiltration of the spine and a measure of its functional integrity.

Rotation of the spine is confined almost exclusively to the cervical and lower lumbar regions. The head can be rotated beyond the ability of the movements of the atlas upon the axis only by virtue of the rotation of the lumbar vertebrae. Holden shows that this can be demonstrated by the following maneuver:

"Sit upright with your head and shoulders well applied to the back of a chair; the head and neck can be rotated to the extent of 70°. Lean forward so as to let the lumbar vertebrae come into play; you can then turn your head and neck 30° more."

Dr. Frederick A. Jostes (*J. Bone & Joint Surg.* 20: No. 4, Oct., 1938) has given the following valuable outline for physical examination of the back:

I. Inspection (standing posture).—

A. Posterior view:	List: Homolateral, Contralateral, Alternating		
	Scoliosis: Thoracic	Shoulders:	
			right
			left
	Lumbar	Sacrospinalis	
	Gluteal crease:	Relaxation	Atrophy
	Position of posterior superior spine		
B. Lateral view:	Chest { flat	Back { round	
	{ elevated	{ straight	
	Lordosis	Abdomen	
	Shoulder girdle rotated to	Pelvis rotated to	

II. Palpation:

Palpable tenderness:

Iliolumbar:	right	left	Lumbosacral:	right	left
Sacroiliac:	right	left	Sacrospinous:	right	left
Piriformis:	right	left	Sciatic nerve:	right	left
Sacrospinous:	right	left	Interspinous ligaments:	right	left
Vertebral spines:	right	left			

III. Active Movements:

Standing:

Forward flexion:	Lateral left	Lateral right
Hyperextension:	Rotary left	Rotary right

Sitting:

Forward flexion:

Various signs have been described, mostly based on elicitation of spasm or pain as indications of the location of a back lesion. They are:

Patient standing—Lucas's Sign.—"This test is performed while the patient is standing with his back to the examiner. He is instructed to bend forward and touch his toes. He usually flexes his knees in order to carry out this command. While the patient stands in this position with his fingers touching his toes, the examiner, gently at first and later forcibly, forces first the right and then the left knee into complete extension. Then both knees are straightened at the same time. In lumbosacral, lower lumbar, sacroiliac, and gluteal disturbances, these movements will be accompanied by pain, and the knee will snap back into flexion. The test is helpful in localizing the lesion."

Patient supine—Goldthwait's sign.—"The patient lies supine with both legs on the examining table. The extended leg, on the side of which the patient primarily complained, is flexed on the abdomen. Normally it should be possible to raise this limb to a right angle with the examining table before pain, muscle spasms or shifting of the pelvis occurs. The leg should be raised slowly with one hand under the lower part of the patient's spine. As the hamstrings tighten, leverage is gradually applied to the side of the pelvis. If pain is brought on before the lumbar spine begins to move, a lesion, either arthritis or a sprain of the ligaments involving the sacroiliac joint, is probably present. If pain does not come on until after the lumbar spine begins to move, the disease or injury may be in either the sacroiliac or the lumbosacral articulations but is more likely to be lumbosacral. The test should be repeated on the other leg. If the lesion is lumbosacral, pain is felt when either leg is raised to approximately the same height; if the lesion is primarily sacroiliac, it is possible to raise the leg on the less involved side to a much higher level than the other without pain."

Lasègue's sign.—"This test is similar to the Goldthwait test. The sign is positive when, with the knee extended, flexion of the thigh is markedly limited or causes pain. The Lasègue contralateral sign is positive when raising the

leg causes pain on the other side in the region of the tuber ischii, sometimes in the lumbar region and at other times down the entire leg.

"While the patient lies supine, the examiner places one hand under the patient's heel. The other hand is placed on the knee. With the limb extended, the examiner flexes the thigh on the pelvis. Raising the limb only a few centimeters suffices to cause pain in the region of the sciatic notch, at the point of the emergence of the nerve. The patient feels severe pain and offers resistance when the thigh is flexed on the pelvis with the limb extended, but if one flexes the leg on the thigh, he can flex the thigh on the pelvis without producing pain.

"To make certain that the pain is not due to sciatica, the examiner lifts the patient's leg while fixing the pelvis on the same side by pressing heavily with his hand on the region of the homolateral antero-superior iliac crest. The fixation of the pelvis prevents the stretching of the sacrolumbalis muscle but not of the sciatic nerve, and permits raising of the leg to an angle of 90 degrees without, or practically without, lumbar pain unless it is due to sciatica. The more acute the angle (formed by the leg and the table) at which lumbar pain is first experienced, the more severe is the involvement of the sacrolumbar muscle. The test should be performed on both legs. The angle to which the legs can be raised without causing pain or spasm may vary as the pain may be more intense on one side."

Patient prone—face down—Ely test.—"In the presence of traumatic and inflammatory lesions of the spine, if the prone-lying patient's heel is forced to touch his buttock, the pelvis or lumbar spine will rise from the table. A positive Ely sign is an indication of a lumbosacral lesion. Ober expressed the belief that Ely's sign indicates a contracture of the fascia lata."

Patient on the side—Ober test.—"Ober discovered that the iliotibial band is an important factor in the occurrence of lame back, with or without an associated sciatica.

"The method of eliciting the abduction sign: The patient lies on his side, with the thighs next to the table flexed enough to obliterate any lumbar lordosis. The upper leg is flexed at a right angle at the knee. The examiner grasps the ankle lightly with one hand and steadies the patient's hip with the other. The upper leg is abducted widely and extended so that the thigh is in line with the body. If there is any abduction contracture, the leg will remain more or less passively abducted, depending on the shortening of the iliotibial band. This band can be easily felt with the examining fingers between the crest of the ilium and the anterior aspect of the trochanter. In some cases the pain on one side can be increased by doing the abduction test on the opposite side. The pain will be increased in these cases also, if the patient is asked to stretch his tight iliotibial band on the affected side while standing and leaning the hip towards a table, keeping his body upright.

"This sign is present both in the conscious and in the anesthetized patient. If there is no contracture present, the thigh will abduct beyond the median line."

Intervertebral Disk Syndrome.—In the diagnosis of sciatica and low back pain due to lesion of the intervertebral disks, the history and physical examination should be relied on rather than the x-ray or intraspinal injections of lipiodal or air, etc. The significant parts of the history have been discussed (see p. 108). They are (1) history of trauma, usually minor trauma; (2) distribution of pain or paresthesia over the lower back and sciatic nerve area (unilateral in 78 per cent of cases); and (3) intermittency of symptoms. The important physical signs are: (1) tenderness or paresthesia over the sciatic

nerve distribution: there may be anesthesia enough to allow a hypodermic needle to be driven into the skin without pain; (2) limp; (3) deformity of the back in the region of the fourth or fifth lumbar vertebrae; (4) limited leg raising—Lasègue's sign (82 per cent of cases); (5) diminution of the Achilles reflex on the affected side (77 per cent of cases). Special tests to show that pressure is the cause of the pain and that increase of pressure intensifies the pain are (1) the snuff test to induce sneezing; (2) occlusion of both jugular veins until the face is flushed and head is full which aggravates the pain (Naffziger: *J. Bone and Joint Surg.* 20: 444, 1938). (3) Lewin's artificial fever test. Hyperpyrexia will ease pain due to arthritis, muscle spasm or fibrositis, but does not help or makes worse the sciatic pain due to a vertebral disk syndrome.

Spina bifida is a congenital defect in the closure of the neural arches—laminae and spinous processes—of the vertebrae, most frequently of the lumbosacral region. It occurs in about 0.1 per cent of newborn infants, and is a serious condition in that about 90 per cent of deaths occur in the first few days or weeks of life.

There are many varieties and forms, nearly every author presenting his own classification. The defect may be small, with skin and fascia covering it over; these cases present few symptoms or signs and go undetected in most instances. The defect may be the site of a lipoma, or it may have a tuft of hair growing from the skin over the site. ("The horse-man" or "the lady with the horse's mane" of the side show.) The skin and fascia over the defect may be thin and allow the protrusion of the meninges—meningocele, recognized by the fact that it is a fluctuating tumor. The meningocele may contain spinal nerves or the cord—meningomyocele. Either form may rupture and become infected. And the defect may cause malformation or developmental defect of the nerves or cord, causing symptoms. The name *spina bifida occulta* is applied to meningocele with no outward signs, but resulting in trophic, sphincter, or peripheral nerve signs.

Lumbosacral spina bifida may cause disturbances in upper parts of the nervous system. Arnold (*Beitr. z. path. Anat. u. z. allg. Path.* 16: 1, 1894) described a malformation of the hindbrain which was more fully studied by Chiari (*Deutsche. d. Akad. u. Wissensch. Math. Naturw.* Cl. 63: 71, 1895) and described a case in which the fourth ventricle extended downward in spina bifida. Lichtenstein (*Arch. Neurol. and Psychiat.* 44: 792, Oct., 1940; and *Arch. Neurol. and Psychiat.* 47: 195, 1942) reports hydrocephalus, Arnold-Chiari's deformity, stenosis of the aqueduct of Sylvius, and other anatomic defects which he regards as caused by fixation of the distal spinal cord and meninges by the spina bifida.

Such cases, and cases of large meningocele, especially with rupture and infection, causing paralysis of the lower extremities and sphincters, do not concern the clinician, except that they are contraindications to operative interference, which does no good.

Spina bifida occulta may result in: (1) loss of the knee jerks; (2) paralysis or anesthesia in the course of the peripheral nerves of the lumbar and sacral

plexus; (3) incontinence of bladder and rectum; (4) ulceration of the feet or toes, auto-amputation of the toes, conditions much resembling the dysraphia of syringomyelia.

The muscles of the spine are particularly likely to be the seat of myositis ossificans traumatica. (See description under extremities.)

Radiculitis.—One of the chief interests the general diagnostician has in the state of the spine is in the syndrome known as radiculitis, first described by von Bechterew (Neurol. Centralbl. 12: 426, July 1, 1893). The conception is quite simple; it is that spinal inflammation or curvature produces a pachymeningitis with irritation or a direct involvement of the sensory ganglia and roots of the spinal nerves which create referred pain to the abdomen or chest, mimicking such diseases as pleurisy, gall bladder disease, appendicitis, renal colic, and general abdominal pain. Literature on the subject is quite abundant (see Gunther and Kerr: *The Radicular Syndrome in Hypertrophic Osteoarthritis of the Spine*, Arch. Int. Med. 43: No. 2, Feb., 1929; Ussher, Neville: *The Viscerospinal Syndrome*, Ann. Int. Med. 13: No. 11, May, 1940; Vanderhoof: *Spondylitis and Abdominal Pain*, J. A. M. A. 74: No. 25, June 19, 1920; Wells and Atsatt: *Ann. Surg.* 29: 661, Oct., 1934). The pains are aggravated on movement of the spine, sneezing, coughing, straining at stool, etc. They may imitate any of the great classic visceral diseases and for the unwary surgeon constitute a pitfall. Carnett, in a series of papers (see pp. 100), has ascribed many of the abdominal complaints which result in unnecessary operations to curvature of the spine and arthritis of the spine. My experience has been that while undoubtedly thoracic and abdominal girdle pain results from real spinal disease (see p. 91), still this idea, ingrained in an internist's head, may become quite as much of a fad as many other ideas so ingrained. Undoubtedly it is a diagnostic pitfall, but it is two-edged and cuts both ways.

Chapter 8

DISEASES OF THE CARDIOVASCULAR SYSTEM

General Pathology.—The commonest lesions affecting the cardiovascular system are those resulting from *degenerative disease of the arteries and arterioles*—arteriosclerosis and hypertension.

Inflammation is the next commonest form of lesion—rheumatic fever first, syphilis next, and last in frequency bacterial endocarditis from streptococcus and, rarely, gonococcus and pneumococcus.

Neoplastic disease affects the cardiovascular system only with the greatest rarity.

Congenital malformations, while not common, constitute a definite group of heart disease.

Intoxications, both endogenous (thyroid) and exogenous, disturb the functions and damage the structure of the circulatory system quite frequently.

Etiology.—Cabot is responsible for pointing out the great groups of etiological factors in heart disease and the proportionate frequency of occurrence:

	PER CENT
Degenerative (hypertensive, arteriosclerotic nephritic)	64.0
Rheumatic	23.0
Syphilitic	9.0
Congenital malformation	1.0
Thyroid heart	1.0

Clawson (Am. Heart J. 22: No. 5, Nov., 1941) in a series of 30,265 autopsies found the incidence of types of heart disease as follows:

	PER CENT
I. INFECTIOUS	36.0
A. Rheumatic	18.0
Acute	2.0
Recurrent	1.8
Valvular	13.0
Adherent pericardium	0.8
B. Bacterial	11.0
C. Syphilitic	7.0
II. NONINFECTIOUS	63.0
A. Hypertensive	55.5
Myocardial insufficiency	24.0
Coronary sclerosis	20.0
Renal insufficiency	3.8
B. Coronary sclerosis with low B. P.	6.2
C. Pulmonary hypertension	1.5
D. Miscellaneous	0.2
(Thyroid, beriberi, etc.)	
(For some of the very minor groups, consult original paper.)	



1.
Inspection



2.
Palpation - the Pulse



3.
Palpation - Apex



4.
Palpation - Base



5.
Percussion



6.
Auscultation - at apex
and three other spots
indicated

Fig. 32.—Examination of the circulatory system.

Routine.—**I. INSPECTION.**—

General—Edema, dyspnea, pallor, cyanosis, gait, position in bed, petechiae.

Regional—Heart impulse. Hypertrophy of heart. Systolic re-
tractions, intercostal spaces, and costal margins. Broadbent's sign

Pulsations over the chest. Abnormal collateral vessels.

Loss of pulsations over precordium. Pericarditis with effusion.
Myocarditis.

Pulsations in the neck.

Pulsations in brachial arteries.

Cyanosis of lips, fingernails, skin. Clubbed fingers.

Distention of veins of neck, chest, and abdomen.

Pallor, loss of pulsation of vessels of arms or legs.

Ulceration.

II. PALPATION.—

A. Pulse.—Palpate both radial arteries simultaneously. Palpate
for:

Rate—counted for a full minute. Equality and synchrony
of the two pulses.

Rhythm—regular or irregular. If irregular, relation to
respiration and presence or absence of a dominant rhythm.

Volume—magnus, parvus, tardus, rarus, celer.

Special signs (to be looked for when indicated):

Corrigan's pulse.

Capillary pulse.

B. Heart.—Locate point of maximum impulse. Feel for thrills
Hypertrophy. Mitral stenosis. Aortitis. Aortic stenosis.

III. PERCUSSION.—Percussion of first interspace on each side of manu-
brium. Aneurysm. Mediastinal growth.

IV. AUSCULTATION.—

A. At apex—mitral area.

B. At fifth interspace close to sternum (tricuspid).

C. At second right interspace (aortic).

D. At second left interspace (pulmonic).

E. At third left interspace next to sternum (for aortic re-
gurgitant murmur).

F. All over precordium and around the chest to the left, and
into the carotid vessels.

*Auscultation of heart to be repeated with patient sitting, recumbent, and
after exertion.*

V. BLOOD PRESSURE.—In connection with blood pressure, consider the
condition of the walls of palpable arteries. These and also examina-

tion of the urine for albumin, casts and sugar and of the arteries of the retina should all form a judgment as to whether hypertensive or sclerotic general arterial disease is present.

VI. EXAMINATION FOR CARDIAC FAILURE.—

A. *Congestive Failure.*—

1. Observe breathing rate, orthopnea, etc.
2. Auscultation at the bases of, and behind, the lungs for râles, indicative of chronic passive congestion.
3. Percuss thorax and especially behind it for evidence of hydrothorax.
4. Palpate abdomen for ascites, enlarged liver.
5. Palpate ankles for edema.
6. Urinalysis for albumin and casts.

B. *Anginal Failure.*—History of anginal attacks, evidence for disease of the coronary arteries, coronary thrombosis, or myocardial infarction.

C. *Failure of Pericardial Origin.*—

1. Pericardial friction rub.
2. Broadbent's sign.
3. Syndrome of acute compression. (1) Small, quiet heart; (2) rising venous pressure; (3) low arterial pressure.
4. Syndrome of chronic pressure. (1) Small, quiet heart; (2) high venous pressure; (3) ascites and enlargement of the liver.

I. INSPECTION

The important things to learn about the heart are, first, whether it is doing its work, and, second, whether it (includes the pericardium and aorta) is the seat of organic disease which will eventually violate its functional integrity.

To determine these points in order, "inspection should be, first, general, and, second, regional" (Crummer).

Heart failure is divided by the classification of the American Heart Association into congestive and anginal. This very simple category will serve for the present. And upon that basis, inspection is the most valuable method in the entire armamentarium of the diagnostician to determine cardiac failure.

When the advanced stage is present, you immediately recognize it on inspection of congestive failure—the ankle edema, ascites, shortness of breath, sitting position, the dragged and sagging facies, the dusky, dirty beginning cyanosis. Earlier you detect the first stages of congestive failure by observing your patient in action—varying degrees of dyspnea.

The onset, degree, and gravity of dyspnea is the most delicate measurement of the extent of congestive failure. From the slight increase in respiratory effort initiated by going upstairs, the use of two pillows in bed, through

the stages where effort is the right name for any exertion, and later when no position in bed is comfortable, but an upright position in a chair; still later, leaning over with the forehead on a support, respiration marks the degree of myocardial weakness. With the onset of relative tricuspid insufficiency, however, the prone position can be resumed. "When a patient with edema and other manifestations of cardiac decompensation is found lying comfortably in bed, a diagnosis of relative tricuspid insufficiency is almost certain."

Through all these stages of painful (dys) breathing (pnoea) the face becomes increasingly more haggard and anxious.

No wonder Corvisart could come into a room and, seeing a portrait of the defunct master of the household, exclaim, "That man will die of heart failure."

Edema, the other great sign of congestive failure, can also be identified by inspection as to what stage it is in. It begins in the ankles. For the first few months the skin is white and pits easily. After a lapse of time, the skin becomes thick, leathery, red, and eczematous. Edema extending above the knees is of grave prognostic significance. Enlargement of the abdomen suggests ascites; it may come early or late. Bilateral edema of the hands is more often characteristic of nephritis, but can be cardiac. Edema of the face, when local, usually means mediastinal disease.

The facies of the patient with anginal failure is equally striking. It has never been formally described in the literature, but every clinician is familiar with it, even if subconsciously. The story is told of Emmanuel Libman that he attended a state dinner in Washington, at which President Harding presided. Libman, who had never seen him before, asked his dinner companion, "Who is the Vice-President now?"

"Calvin Collidge," was the reply. "Why?"

"Because he soon will be President. That man has a coronary thrombosis."

"Cyanosis means mitral disease, pallor means aortic disease" is an old aphorism which, with some reservations and explanations, holds much truth.

The facies of coronary disease is elusive to description. It really shows best in the back of the neck, to indulge in an Hibernianism. A curious, indefinite pallor, not cachexia, but resembling cachexia as the mist resembles rain, an emaciation of the insertion of the sternomastoid, and the trapezius as if the excess fat and only the excess fat had been dissolved away from around the skin overlying the tendons. "How he has broken!" you exclaim of a friend you have not seen for years. Yes, broken is the word. It came suddenly, though this you may have to elicit by the history if you are not previously acquainted with the patient. If the history is obtained from a relative, out of charitable consideration for the patient, get the history of when he "broke." He may not have had a pain to herald the onset.

How different is the picture of functional heart disturbance—neurocirculatory asthenia, let us say. Young men, with pulses of 140 and blood pressures of 170/80, could run around in a circle half the morning at the army post and never have to stop to catch an extra breath.

For the other point—the heart as the seat of organic disease—inspection will lay the groundwork for your subsequent investigations. The location of the apex beat, the tumult or quietness of the precordium, the throbbing of the carotids and brachials, the systolic retraction of the intercostal spaces, and the end of the sternum described by Broadbent. “Systolic depression of one or more intercostal spaces to the left of the sternum, and the adjoining costal cartilages which may be caused by the heart dragging on them at each systole, through the agency of the pericardial adhesions. The systolic retraction of spaces alone is, however, not a trustworthy indication, as it may be due to atmospheric pressure, more especially when the heart is much hypertrophied. When the costal cartilages or lower end of the sternum are dragged in, there can be little doubt of the diagnosis, as this could not be affected by atmospheric pressure. . . . Systolic retraction of the lower portions of the posterior or lateral walls of the thorax may indicate the presence of a universally adherent pericardium. Such retraction may, however, be seen though the pericardium is not adherent to the heart but only to a larger extent than normal to the central tendon of the diaphragm and the muscular substance on either side, and to the chest wall as well. The explanation seems to be that the portion of the diaphragm to which the pericardium is adherent is dragged upwards at each systole of the heart, so that the points of attachment of the digitations of the diaphragm to the lower ribs and costal cartilages are dragged inwards and retracted.” (William Broadbent: *Adherent Pericardium*, Tr. M. Soc. London 21: 1898.)

Distention of the veins of the neck never meant anything definite to me so far as the heart is concerned.

Distention of the superficial veins over the chest and abdomen is a striking feature, positively diagnostic when marked, of obstruction of the vena cava inferior below the opening of the hepatic vein. This collateral circulation is formed by anastomosis of the external mammary veins above with the superficial epigastric and superficial circumflex iliac veins below.

The initial facies is described as a cyanotic flush of the malar eminences with dilated capillaries of the skin in that region. Although described with great confidence repetitiously in all textbooks, it has never seemed to me of much value, nor indeed often easy to identify even when it is known that mitral stenosis exists.

Cheyne-Stokes respiration is indicative of some circulatory disturbance in the respiratory center, rather than heart muscle failure. “For several days his breathing was irregular; it would entirely cease for a quarter of a minute, then it would become perceptible, though very low, then by degrees it became heaving and quick, then it would gradually leave again; this revolution in his state of breathing occupied about a minute” (John Cheyne: *A Case of Apoplexy in Which the Fleishy Part of the Heart was Converted Into Fat*, Dublin Hospital Reports, 1818). Stokes described it thus: “But there is a symptom which appears to belong to a weakened state of the heart, and which therefore may be looked for in many cases of the fatty degeneration. . . . The symptom in question was observed by Dr. Cheyne. . . . It consists in the

occurrence of a series of inspirations, increasing to a maximum, and then declining in force and strength until a state of apparent apnea. In this condition the patient may remain for such a length of time as to make his attendants believe that he is dead, when a low inspiration followed by one more decided marks the commencement of a new ascending and then descending series of inspirations. This symptom, as occurring in its highest degree, I have only seen during a few weeks previous to the death of the patient" (*Diseases of the Heart and Aorta*, Dublin, 1854). Hippocrates described it in the "Case Histories": Philiscus "whose respiration was like that of a person recollecting himself."

Inspection is the most reliable physical method of detecting an aneurysm of the aorta. When not immediately noticeable, the aneurysmal pulsation can be made out by careful inspection across the chest wall with the eye on the level of the chest wall, the light coming from the side of the patient opposite the examiner.

II. PALPATION

A. Palpation of the Pulse

The first act of palpation should be that of the *pulse*. It is just as easy to learn to palpate both radial pulses and perceive whether they are synchronous in rate and strength, or whether one is entirely missing or not. It is true this precaution of feeling both pulses will seldom be rewarded with any positive results, but since it requires no extra time or effort, it might as well be routine, and on the very rare occasions when something positive comes to light, the returns are richly rewarding.

Aneurysm involving either the innominate or the common carotid will make the radial pulse on that side slower to reach the wrist, and smaller when it arrives. Aneurysm of the subclavian or axillary arteries will either obliterate or greatly diminish the pulse. Thrombosis or embolism of the upper arteries will obliterate the radial. Tumor pressing on the larger trunks will have an effect. Coarctation of the aorta gives large throbbing radial and carotid pulses with small, scarcely palpable pulsations in the femoral, popliteal, and dorsalis pedis arteries. Do any normal persons have a difference in size of the two radial pulses? Perhaps.

The pulse should always be counted for a full minute—certainly, at least, when the patient is seen for the first time.

All of our pulse lore about rate and rhythm has been completely illuminated by the studies of electrocardiography. But the clinician after having learned his lessons from the electrocardiograph, can in most instances by palpation read into the record physiologic interpretations far beyond anything our predecessors knew.

(a) *Rate*.—The more experienced the clinician is, the more importance he attaches to the *rate* of his patient's pulse. For prognosis, especially, the rate during shock, acute poisoning, appendicitis, pneumonia, coronary disease, apoplexy, etc., conveys a multitude of messages.

In a healthy adult the pulse is 72 per minute, in the fetus, 140 per minute; during the first year of life, about 120 per minute, during the third year 95, eighth to fourteenth year, 84. It is slightly more rapid in the female. In the recumbent or sitting position, it is slightly slower than when standing. Exercise and digestion increase the beat slightly.

How fast is the human heart capable of beating? Lyon (*Excessively Rapid Heart Rates*, J. A. M. A. 108: April 24, 1937) collected fifteen cases from the literature with a ventricular rate of 280 or over, and added one of his own in which the rate was from 310 to 313 as recorded electrographically. This was a female Negro infant, four and one-half weeks old, who died three weeks later and a streptococcic meningitis was found at autopsy. Between bouts of the excessively rapid rate, the heart rate fell to 130 or 180. Of the sixteen cases recorded by Lyon, the rate in ten was confirmed by graphic tracing; thirteen resumed a normal rate; three died; outcome not stated in one. The associated pathology was grippe, exophthalmic goiter, congenital heart disease, encephalitis, etc. The electrocardiographic diagnosis was always paroxysmal auricular tachycardia or auricular flutter. The upper limit of the ventricular rate seems to be about 300.

Drugs, unless they fall into the group which produce myocardial change, can practically be discounted by the clinician in assessing an obscure reason for a fast or slow pulse. None of the habit-forming drugs have any permanent influence of this sort. Caffeine and tobacco have some effect in controlled pharmacological experiments, but not in the habitual user. Adrenalin and atropine are the only commonly used drugs that increase the heart rate. Amyl nitrite, nitroglycerin, and aconite also accelerate it. Digitalis slows the pulse, particularly the pulse of auricular fibrillation.

Tachycardia.—Rapid pulse occurs with practically all *febrile states*. The old rule is that the pulse rate should increase ten beats to every degree rise in temperature above normal. Typhoid is classically an exception, producing a comparative bradycardia. The fever in typhoid may be 104° F., calling for a pulse rate of 132, when actually it is 100. Tuberculosis is the exception in the other direction—the pulse rate may be 100 or 110 with a temperature of 99.5° or 100° F. In most diagnostic riddles where tachycardia is the central point, tuberculosis is found to be the answer. The runners-up are neurosis, neurocirculatory asthenia, and goiter.

Thyroid intoxication is the next commonest cause of persistent tachycardia. It is partly due to the pharmacologic effect of the thyroid hormone and partly to more rapid metabolism with increased heat of the body. The rate is usually from 100 to 150. The maximum is 200. Usually it is faster in the morning, a contrast from the pulse of myocardial damage.

The heart rate, according to Heitzler, is an indication of the severity of the disease. The electrocardiographic pattern is not changed, except for shortening of the interval between the complexes from the normal. Auricular fibrillation and congestive failure may supervene, but this is comparatively rare,

and it is a matter of astonishment to all clinicians that the myocardium can take such a long-continued pounding as it does in exophthalmic goiter and still stand up.

Neurocirculatory Asthenia.—D. A. H. (disordered action of the heart), soldier's heart, vagal heart—is characterized by persistent rapid pulse and high blood pressure, with no other changes discernible in the circulatory organs. Bona fide cases are almost exclusively confined to those inducted into military service, and the underlying cause seems to be good old-fashioned fright. My own impression of these cases was that the thyroid secretion is disturbed, although the basal metabolism is not markedly raised nor the thyroid enlarged. It can occur, of course, under any conditions of anxiety. The blood pressure is not invariably raised.

Paroxysmal tachycardia is a clinical entity consisting of attacks of sudden onset of extremely rapid heart rate, with spontaneous subsidence after a period which may be hours or days in duration and abrupt return to normal rate. The condition was described by Stokes (1854) and Cotton (1867), but the first extensive description is J. S. Bristowe's (1888). Bouveret of Lyons christened it (1889). Cotton noted the sudden onset of a heart rate of 230, the sudden drop to 80, after a three weeks' period. Rapid respiration and distress were noted during the paroxysm. Bristowe wrote, "The attacks came on suddenly and after a week left her as suddenly; pulse varied from 180 to 192 a minute. A few weeks later she had a recurrence of palpitation when the cardiac beats were counted at 246. The remarkable feature was the apparent absence of distress."

The pulse is invariably regular. Age or sex is not a factor, cases being reported at ages of twenty to sixty, males slightly in the preponderance. The prognosis for life or cardiac failure is good. I have followed two of these cases for years—in one the attacks suddenly ceased to occur for no known reason, in the other they have continued to recur, but with no impairment of general health. One man's guess is as good as another as to the cause. (See chapter on electrocardiograph, p. 791.)

Auricular flutter may be suspected when the pulse suddenly jumps at the rate of multiples of the normal, 72 (i.e., 144, 288). It is related to auricular fibrillation—the same causes and conditions—except that the rate is regular.

Ventricular tachycardia is far commoner than usually stated in the texts. It is a frequent cause of sudden death when the diagnosis is turned in as angina pectoris. It results from myocardial changes either due to acute or chronic focal infection or to the toxic effects of many newly introduced drugs, especially some of the modern anesthetics. Many an operative death has this etiology.

Bradycardia.—Common causes of slow pulse are convalescence from surgical operations, fever, shock, accident, old age, usually with hypertension, jaundice, sunstroke, increased intracerebral pressure.

Heart block and Adams-Stokes' syndrome produce the remarkable states of permanent, extremely slow pulse. The sensation of feeling one of these pulses

for the first time is uncanny; you think the artery has rolled from under your fingers or that the patient is dead. "Mr. Adams has reported a case of permanently slow pulse in which the patient suffered from repeated attacks of an apoplectic nature, though not followed by paralysis. The following case will further elucidate: a male, 68 years old, in whom the onset of the syncopal attacks was three years before, with a pulse rate of 28, many extra pulsations in the veins of the neck were noted (more than twice the pulse rate)." (Stokes: Dublin Quart. J. M. Sc., 1846.)

The best subjective description of an attack is that given by Mackenzie in a letter "written by an old friend of mine who suffered from Adams-Stokes' syndrome, the pulse rate usually being 30 per minute.

"It happened in the middle of the night. I awoke from a quiet sleep feeling a most curious creepy sensation: my functions all seemed to be stopping and in front of me, about two feet from the floor appeared a circular light about two inches in diameter, and brilliant beyond anything I had ever seen. I thought the period of my dissolution had arrived. I was perfectly calm and began to reason with myself whether I should waken my wife (I do not know whether I should have had strength; I was turned from her at the time) in which case she would be greatly alarmed, or leave things to take their course. Before my mind was made up what to do, the light began to contract, and when it was reduced to about half its original size, suddenly went out, but before entirely losing consciousness, I had such a feeling of peace and restfulness as I never experienced before and had just time to say to myself—'There is no after life anyway.'"

The cause of heart block is usually a focus of arteriosclerotic or fatty degeneration in the bundle of His. A gumma in this location will cause the same symptoms, but is of rare occurrence. Infections such as rheumatic fever, influenza, or diphtheria often cause block of usually transitory duration.

Heart block does occur in young patients. Ashman, at the Charity Hospital, New Orleans, found among fourteen patients with complete atrioventricular block, one patient twenty-two years old. Among sixteen patients with partial block was one twenty-four and one twenty-nine years old. Sprague and White (M. Clin. North America 10: 1235, 1927) reported eleven cases of *high-grade block under the age of thirty*. *Congenital heart defect was the cause in about half the cases of juvenile heart block collected from the literature by Lemann (Ann. Int. Med. 7: No. 6, 1933)*. Few have come to autopsy, but clinically there is evidence of a defect in the interventricular wall, with a loud systolic precordial murmur, cyanosis, and clubbed fingers. Many patients, though they have no evidence of congenital defect, carry a slow pulse all through life. Jacquier (quoted by Archigene—These de Paris, 1927) had a patient, who at the age of seventy-eight had a pulse of 26 on awakening, 32 after he had been active a few minutes. According to family tradition, the doctor had commented on his slow pulse at the time of his birth, and he had carried a bradycardia all his life. Rheumatism, diphtheria, and other acute infections account for the cause of block in the rest of the cases. A very surprising feature of heart block in the young is the complete absence of serious symptoms. The prognosis for long life seems to be good. Hyman (J. A. M. A.

94: 27, 1930) had a patient who at fifty-seven years had a complete block; he had known of his slow pulse since the age of twelve and could always get sick leave from school by having his pulse counted. He had worked all over the world at severe and straining tasks, and had never experienced syncope.

INCIDENCE.—In 9,000 cases, studied electrocardiographically, A-V block was found in 581 (6.5 per cent). Among 2,825 patients studied at the Charity Hospital, New Orleans, disturbance of the A-V conduction system was found in 264. Sino-auricular block occurs in its transient form so commonly as to be incomputable.

AGE.—In Ellis' (Am. J. M. Sc. 183: No. 12, Feb., 1932) series the ages of the patients ranged from nine weeks to seventy-eight years. Seventy per cent were over forty years of age.

FORMS.—In White's series of 69 cases of A-V block, thirty-five were due to coronary disease, nineteen to rheumatic infection, one to congenital defect, one to syphilis, nine to digitalis medication, and four, cause unknown. In Ellis' series in twenty-nine out of forty-three cases, the block was permanent, in the other intermittent or temporary.

The disability of block with Stokes-Adams syndrome is considerable. Sir W. T. Gairdner, who described his own case of heart block, wrote four years after the slow rhythm began (30 beats to the minute) and two years before his death at eighty-two: "I am wonderfully free from all the symptoms that usually go with organic heart disease. My sleep is almost always undisturbed. Although I am a little uncertain in my gait, I can go from one room to another or even up a simple stair, taking plenty of time and assisted by the railing; but for the last two years my position has been with few exceptions recumbent, and repeated attempts have shown me that it is practically impossible to cross the street or go into the garden opposite the home except in a wheeled arm chair; and along with this there is a feeling of perpetual weariness that never leaves me even after the soundest sleep."

Branch bundle block or arborization block constitutes, in my experience, quite a definite syndrome and one so frequently met with when one is sufficiently alert to its existence as to require electrocardiographic confirmation, that it constitutes a common form of heart failure. King (Am. Heart J. 3: 505, 1928) found it in nine out of one hundred unselected cases of heart disease. Arteriosclerosis was the pathologic basis in 69.5 per cent, syphilis in 9 per cent, rheumatic fever in 9.7 per cent, and unknown etiology in 11.8 per cent of 155 cases (King: Am. J. M. Sc. 187: No. 2, Feb., 1934). The average age of the arteriosclerotic group was sixty-one years, of the syphilitic group, forty-two years, of the rheumatic group, forty-two years (King, op. cit.). Men constitute 73 per cent, women, 27 per cent of patients.

Block of the left intraventricular bundle (new nomenclature) is far more frequent than of the right—ninety-four left, six right. Bohning, Katz, Langerdorf, and Blumenthal (Am. J. M. Sc., Nov., 1941) divide the types into left ventricular delay (35 cases), right ventricular delay (5 cases), and indeterminate, representing delay of right and left ventricles (30 cases).

The type and location of the block are not of very much importance in recognizing or suspecting the disease clinically. In the type with arteriosclerotic etiology—the common clinical picture—the onset is sometimes sudden with an anginal episode, or gradual. The course is the same in either case because the patient does not come back after the anginal attack, and gradually becomes more dyspneic on exertion, with weakness, a peculiar pallor of the face and back of the neck, with emaciation of these parts. He looks and feels like a sick man, although he cannot localize his illness. There may or may not be hypertension. The retinal vessels nearly always show change. There is always some cardiac hypertrophy to the left. In most cases there is an apical systolic murmur, or a systolic aortic murmur. About half have gallop rhythm. Reduplication of the first sound would be a natural finding and is found in 56 per cent of the cases. Râles at the base of the lung are common, and there may be a palpable liver, slight ankle edema, and albuminuria. The signs of congestive failure are, however, minimal or smothered. A few have pulsus alternans. Ring and MacEachern (*Am. J. M. Sc.* 183: No. 4, April, 1932) described a method of demonstrating the reduplicated or split thrust of the right and left ventricles by fastening a light broom straw upright over the apex with the patient in the recumbent position.

The prognosis is bad. Of 104 patients traced by King (op. cit.) 76 were dead. The average duration of life was one year for the arteriosclerotic group; ten months for the syphilitic, and eight months for the rheumatic.

(b) *Rhythm*.—The regular rhythm of the heart rate is maintained by the property of rhythmicity of the heart muscle, and the balance between the vagus and sympathetic influences. The forms of irregularity are:

Sinus Arrhythmia—Respiratory Arrhythmia.—It is the irregularity of infancy, childhood, and youth. The rate varies in the respiratory cycle, faster in inspiration, slower in expiration. The slowing corresponds to stimulation of the vagus. It has no serious significance. Mackenzie said, "Its presence indicates the heart is healthy."

In palpating an irregular pulse, determine whether the dominant rhythm of the heartbeat is preserved.

Ectopic beats, extrasystoles, premature contractions constitute a form of irregularity in which the dominant beat is preserved. The irregularity is caused by the interposition of extrasystoles. The impression to the palpating finger is that of dropped beats. The pulse goes 1, 2, 3 pause 4 (1 and 2, 3 in regular order, very much stronger than the others)—1, 2, 3 pause 4, 1, 2, 3 pause 4. The irregular beats may come at regular intervals—every other, every third, fourth or fifth beat—or may be interspersed every once in a while. The patient usually feels the extrasystoles, calls them "skips" or "skipping heart" or "palpitation." In contrast to sinus arrhythmia which is the irregularity of youth, extrasystole is the irregularity of middle age and senescence. The condition has been known to clinicians for years under the term "intermittent pulse." Sir James Paget described his own case thus: "An irregular pulse. In the early part of July, 1886, I chanced to find that my pulse beat

irregularly. It may have done so before I observed it, for I was not in the habit of feeling it, and only by chance did so now, while sitting with my hands clasped so that the beating of the digital arteries could be felt in the mutually compressed fingers. The irregularity was in the frequent missing of one beat. Three or four or more would follow regularly, then one would be missing; and then in exactly the due time, the regular beats would again follow. The defect was almost wholly in respect of the time of the beats. At the most I could feel that the beat which followed after an intermission was a little stronger than the others. With this irregularity I was not conscious of any change in my feelings of health. Dr. Andrew found nothing wrong in the heart's sound. After the irregularity had been observed for two months, during which time I had never felt so many as fifty beats, and seldom as many as fifteen without an intermission, my holiday time came and I went to the Pyrenees. I took no special care of myself, but ate and drank the usual foods and wine of each place. I could walk much better than I expected, as much as at least twelve to fifteen miles, including 2,500 feet of rather steep and very rough ascent. Still the irregularity of the pulse continued. At the end of five weeks I came home quite refreshed. Now this irregularity of the pulse had continued unchanged in all the variety of home life and all the different varieties of holiday life. I will not be so credulous as to think I can explain it." (Paget: *Studies of Old Case Books*, London, 1891.) Sir James died in 1899 at the age of eighty-five.

Broadbent wrote, "The term 'intermittent' is employed to designate the pulse when a beat is completely missing from time to time, while the pulse in the intervals is perfectly regular. The intermission may happen at regular and definite periods every four, six or up to twenty beats. The interval produced by the missing beat is not usually quite equal to two beats, and the succeeding beat feels stronger—from the pressure in the arteries having run down. The patient may or may not be conscious of the intermittent action of the heart" (Broadbent, *The Pulse*, 1890).

Extrasystoles indicate a disturbance of the property of irritability of the heart muscle. Irritability is increased. Some sensitive focal point or other goes into contraction prematurely and sets off a systole. Drugs which irritate the myocardium—tobacco, digitalis, coffee, and alcohol—produce extrasystoles. Exercise should, if this conception be true, by tiring the myocardium, diminish extrasystoles; it usually does, but not by any means always. Otto and Gold (Arch. Int. Med. 38: 2, 1926) indeed in their study of persistent premature contraction found that exercise and epinephrine increased the number. Extrasystoles occurring during a period of dosage with digitalis are among the earliest signs of full dosage. The bigeminal pulse of digitalis is due to an extrasystole every other beat.

"Extrasystoles or intermittent heart occur frequently and are signs of no significance so far as the efficiency of the heart is concerned" (Mackenzie: *Diseases of the Heart*, 1913). This judgment of Mackenzie's, while true in the vast majority of cases, is not invariably and universally so. Mackenzie deserves

great credit for having emphasized the innocuous character of extrasystoles. He accomplished quite a turn-about in clinical thought because up to the time of the publication of his *Diseases of the Heart*, physicians had been inclined to give a guarded to grave prognosis when consulted about extrasystolic arrhythmia. To Broadbent's credit, however, it should be noted that he wrote before Mackenzie, "The constant intermittent pulse appears to have no significance either in relation to the heart, or to the nervous system or to the vital power generally."

Sometimes, however, extrasystoles are the sign of a failing myocardium. Müller, (Nervous Affections of the Heart, Arch. Int. Med. 1: 1, 1908), who always held a graver view than Mackenzie, said, "There is no doubt that extrasystoles in the vast majority of cases are due to incipient or advanced diseases of the myocardium. If a great number of extrasystoles disturb the normal pulse rate, we are always sure of a severe damage to the heart muscle. It is better in practice to consider them as signs of importance and not simply as the manifestation of a nervous heart which commonly passes as harmless."

Mackenzie himself warned that when extrasystoles occurred in the course of a pneumonia, the outcome would be fatal. Laubry (Sur le pronostic de l'extrasystole, Chirurgie, Paris 28: 1933) pointed out that anginal attacks followed by extrasystoles should be regarded seriously. This, I think, is true only when the extrasystoles make their first prominent appearance after the anginal attack or become a troublesomesymptom afterwards. Most patients who suffer an anginal attack will have had the ordinary extrasystoles of middle age before. Bohan (Cardiac Irregularities, Minnesota Med. 17: 624, 1934) warns that extrasystoles occurring in heart rates above 100 are often indicative of myocardial disease. Strickland-Goodall (The Premature Contraction and Its Significance, New York State J. Med. 115: 204, 1922) emphasized the point that when premature beats are developed or increased by exercise, the prognosis is more serious. Auricular and nodal extrasystoles are, of course, more serious than ventricular, and when they arise from different foci, the indication of myocardial disease is more pointed. Raman (Extrasystoles, Indian J. M. Research 28: 249, July, 1940) studied extrasystoles in cases of organic heart disease: four syphilitic, nine rheumatic and fifteen cases of myocarditis of unknown origin. He concluded: "Extrasystoles in themselves have no clinical significance. The prognosis gets worse as the extrasystoles become frequent and persistent." Esler and White (Clinical Significance of Premature Beats, Arch. Int. Med. 43: 606, 1929) take the least grave view. They studied two hundred patients, divided into two equal groups, one with extrasystoles, one with normal rhythm. Each group was subdivided into four groups according to heart rates—Group I, less than 80, Group II, between 80 and 100, Group III, 100 and 120 and Group IV, about 120. They concluded: "Premature beats at more rapid rates did not bear a more serious prognosis than those of slower rates. The presence of premature beats added no gravity to the prognosis. The death rate was actually slightly greater in the 100 cases with normal rhythm."

It certainly is a matter of great importance. Extrasystoles are the commonest form of irregularity met with clinically. The clinician, whether he be internist, surgeon, or obstetrician, should make up his mind what they signify and what to do about them.

Auricular fibrillation is the irregularity of the heart with complete loss of dominant rhythm. The auricle ceases to contract. Its rhythmic contractions are replaced by individual quiverings of individual muscular fibers or by a circularly moving storm of contractions, not sufficiently strong to empty the auricle, called the circus movement. Whichever mechanism is responsible, the A-V nodule which initiates the ventricular contractions no longer is rhythmically stimulated and responds only when not in the refractory phase and with varying degrees of strength.

The pulse at the most then becomes absolutely irregular. The term "delirium cordis" has been applied. Neither in time nor in strength are any of the beats equal or regular. Four or five beats will run off under the examiner's finger, hardly making enough of an impulse to allow them to be counted and then there will be a pause and then a strong beat and then a single weaker beat or two.

In making the diagnosis of auricular fibrillation by palpation of the pulse alone, besides this loss of dominant rhythm, there is a pulse deficit which means that all the beats of the ventricle are not transmitted to the artery. In examining for pulse deficit, do not attempt to feel the radial pulse and listen at the apex at the same time. First count the radial, then the apex beat and then feel and listen simultaneously to make sure.

The onset of auricular fibrillation imposes a serious functional defect on the heart. In most instances it is followed by congestive failure. Most cases of fibrillation occur in the course of mitral stenosis (in mitral stenosis the auricle for years bears an unusual strain and finally gives away), arteriosclerotic or hypertensive heart disease, or thyrotoxicosis.

(c) *Volume of the Pulse* is measured by the amount it rises and the extent of its collapse. This is really dependent on the diastolic pressure. "Pulsus magnus has a high pulse pressure, a pulsus parvus has a small pulse pressure. The term pulsus celer does not refer to the pulse rate inasmuch as it does not mean a rapid pulse but a quick pulse, one which rises rapidly and falls rapidly." (Major, *Physical Diagnosis*.) These distinctions are easy enough to recognize by the palpating finger, but they rarely mean anything in a clinical sense. Of course, the pulsus magnus of aortic insufficiency is notable, but is seen better than felt.

Pulsus alternans is the irregularity of strength of the beat of the pulse. The electrocardiograph does not record it, or at least but rarely. It consists of a small beat alternating with a large beat. Traube described it in 1872 as "a succession of high and low pulses, in such a manner that a low pulse follows regularly a high pulse, and this low pulse is separated from the following high pulse by a shorter pulse than that between it and the preceding high pulse." It can be palpated readily in most instances, or even seen in tortuous

brachial arteries. The blood pressure manometer probably records it best. It is a sign of grave prognosis, a disturbance of the property of contractility of the heart muscle; it means the heart is tired. Mackenzie published some tracings of *pulsus alternans* in 1902. In 1905 Wennebach commented on the condition and Mackenzie wrote: "When I saw his account, I started to re-examine all my patients who had this condition (about a dozen) and I found they were all dead."

(d) *Condition of the Arterial Wall*.—Whether arteriosclerotic changes have occurred in the radial arteries is usually quite evident to the examining finger, and it may be assumed that all the other of the size of the radial (medium-sized arteries) are in the same anatomic condition. This, however, does not necessarily mean hypertension of any degree. On the contrary, it is likely that arteriosclerosis in arteries of this size and hypertension are almost mutually exclusive.

In the presence of signs of peripheral arterial disease of the legs or toes, the *dorsalis pedis*, posterior tibial and popliteal arteries should be palpated. Tortuosity of the temporal arteries does not necessarily mean generalized arteriosclerosis. Hoyt, Perera and Kauvar (*New England J. Med.* 225: No. 8, Aug. 21, 1941) have described temporal arteritis which causes headache.

(e) *The Pulse Signs of Aortic Insufficiency* are quite as definite, evident, and diagnostic as the cardiac signs. They result from the bounding of the pulse due to the fact that the column of blood shot out in systole is not held by the aortic semilunar valves, but some of it falls back into the ventricle; the circulation is dealing with a constantly labile column of blood. It is idle to attempt to improve on the original description of these phenomena.

Corrigan's Pulse, Water Hammer Pulse.—"When a patient affected by the disease is stripped, the arterial trunks of the head, neck, and superior extremities immediately catch the eye by their singular pulsation—the subclavian, carotid, temporal, brachial and in some, even the palmar arteries are suddenly thrown from their bed, bounding up under the skin. The pulsations of these arteries may be observed in a healthy person through a considerable portion of their tract and become still more marked after exercise or exertion; but in the disease now under consideration the degree to which the vessels are thrown out is excessive. Though a moment before unmarked, they are at each pulsation thrown out on the surface in the strongest relief. In the carotids and subclavians they can be examined by the finger, then is felt *frémissement* or the peculiar rushing thrill, accompanying with *bruit de soufflet* each diastole of these vessels." (Dominic John Corrigan: On Permanent Patency of the Mouth of the Aorta, or Inadequacy of the Aortic Valve, *Edinburgh M. and Surg. Jour.* 37: 225, 1832.)

The only condition known to me which imitates the Corrigan pulse is the pulsation in the common carotid at the base of the neck in hypertension as described by Brown and Rowntree (*Right-sided Carotid Pulsations in Cases of Severe Hypertension*, *J. A. M. A.* 84: No. 14, April 4, 1925). The common carotid, in many instances of hypertension, becomes elongated and tortuous, pushing forward into the space beside the sternal insertion of the sternomastoid muscle. The thrust and recession of the angulated artery may be mis-

taken for Corrigan's pulse. Tortuous brachial arteries sometimes appear to move like Corrigan's pulse, but they lack the diastolic collapse when their movements are carefully analyzed.

Duroziez's Sign—Double Shock Sound in the Femoral Arteries.—

"On compression of the femoral artery, a shock or thrill is felt and auscultation reveals a sound similar to the sound of *toc*, or a sound of unique blowing character, a simple intermittent blowing murmur. The entire femoral artery is capable of giving rise to this blowing murmur.

"The intermittent double murmur over the femoral arteries was described in aortic insufficiency; but no one, I believe, has given it the significance it deserves. Everyone has mentioned the murmur appeared in arterial diastole, which quite frequently occurs without compression of the artery. Very frequently it does not appear of its own accord, but must be produced and sought for. The double murmur can be produced in two ways, by means of the stethoscope or by means of the hand. With the stethoscope, pressure is exerted to compress the artery completely; at a certain moment the double murmur will appear; only when the second murmur can be readily produced is it possible to place the stethoscope on the artery without pressure and then gradually slight pressure can be exerted with the hand above and below the stethoscope. Pressure above will produce the second murmur; it is evident that the second murmur is produced by the arteries of the legs which propel the blood backward and in some manner empty the capillaries." (Paul Louis Duroziez: *Du double souffle intermittent crural, comme signe de l'insuffisance aortique*, Arch. gén. de méd., Paris 107: 417, 1861.)

Capillary Pulse—Quincke's Phenomenon.—"The capillary pulse one can see best on one's own fingernail, or better on that of another, in the area between the whitish blood-poor area and the red injected part of the capillary system of the nail bed, with each heartbeat a forward and backward movement of the margin between the red and white part. The fingernails of everyone do not show this white zone. Under these conditions a clear zone on the nails can be produced by even pressure.

"In aortic insufficiency the capillary pulse is especially clear. In a horizontal position of the hand we see a rapid appearance and disappearance of the margin between the red and white zone with lightning-like and evanescent reddening. . . . The index finger is best . . . in the nail bed the average diameter of the capillaries is 0.005-0.008 while elsewhere in the body it is only 0.002-0.006. In another place—namely the retina—is a uniform reddening and diastolic pallor of the papilla." (Heinrich Trenalus Quincke: *Berl. klin. Wchnschr.*, V. 357: 1868.)

The capillary pulse can also be seen in the lips on pressure with a microscope slide, and on the skin (a favorite site is the skin of the forehead) on stroking with the examiner's fingernail until a red line appears. The pulsation is seen at the edges of the red area as a gentle ebb and flow.

B. Palpation of the Heart

Palpation confirming inspection is the most reliable means of physical examination for determining the size of the heart. True, we are able to make out only the left boundary of the heart, but it is a matter of practical experience that when the apex is moved toward the left the entire heart is hypertrophied.

Let us get the technical details out of the way first. In many patients (about one out of five adults) the left border of the heart cannot be made out at all either by inspection or palpation. In most instances this is on account of the fatness and weight of the patient, the thickness of the chest wall. In a few cases it is due to weakness of the heartbeat. The very canny practitioner will think of dextrocardia, but it has never seemed to me such a very good joke if he does not.

Generally a quick glance before putting the hand on the chest wall shows where the apex is likely to be and then the finger confirms. The flat of the palm of the hand may be laid over the heart, in doubtful cases and then the finger used for exact location, much as one would use the low and high power of the microscope. When you do feel it, be exact, and do not go on to any other part of the examination until you have recorded exactly where it is—in what interspace, where in relation to clavicle, nipple, anterior axillary line, etc. If it cannot be felt with the patient erect, ask him to lean forward to bring it out.

What do we feel when and if, as we say, we locate the apex beat? The distinctions left ventricle and right ventricle are purely arbitrary when we come to the general region of the apex of the heart. As nearly as one can say, the right ventricle presents over the front of the chest wall from the right border of the sternum, almost to the region of maximum impulse. The left ventricle comes around in front only over a small area to impinge on the chest wall. Furthermore, the lung covers the extreme left tip of the heart. The part of the heart muscle then which impinges on the chest wall and creates the impulse which we call the apex beat is a small part of the left ventricle and a large part of the right ventricle. Major (*Physical Diagnosis*, op. cit.) prefers to call this the point of maximum impulse. "The apex itself is covered by the lung and is usually 0.5 cm. to the left of the point of maximum impulse." I agree to that, but it is a matter of small practical consequence and for brevity's sake I find myself saying apex beat without any violation of scientific sense.

The point of maximum impulse or apex beat is felt in the fifth interspace inside the nipple line (in males) almost exactly in the midclavicle line. It naturally changes somewhat on change of position. A deep inspiration may interfere with sharp palpation of it. In asthenic individuals with dropped heart it may be in the sixth interspace. But these variations are not marked and its wanderings are never wide under normal conditions.

It is displaced by pleural fluid accumulations (although not often, see p. 438), and by mediastinal tumors. It is pulled to the left by pleural adhesions. In adhesive pericarditis it may be a retraction rather than an impulse. But all these conditions are of the utmost rarity.

In any form of hypertrophy of the cardiac muscle the P. M. I. or apex beat is displaced to the left. Sometimes it reaches as far as the midaxillary line. It may rise so that it is in the fourth interspace.

For this reason and because it is simple and easy to detect, in the majority of cases it is one of the most important physical signs we have. When the heart is hypertrophied, it means organic cardiovascular disease.

Since the introduction of the electrocardiogram and the use of the terms, left axis and right axis deviation, there has been a renewal of the conception among medical men that there is a distinct right or left heart hypertrophy. This conception is fundamentally false. When the heart muscle hypertrophies, it hypertrophies all over. The slightest glance at the heart muscle bundles dissected and unrolled, showing their fundamental continuity, is sufficient to show this, once and for all. True, in aortic disease and hypertension the left ventricle's hypertrophy predominates over the right, and in mitral disease and pulmonary obstruction, the right over the left, but when any part of the ventricles hypertrophy, they hypertrophy all over. Nothing is more futile and fatuous than to see a diagnostician hammering away beyond the right border of the sternum in an attempt to demonstrate right ventricular hypertrophy as a single entity.

Not only is the heart muscle organically bound together by the interlacing and continuity of its muscle bundles, but it is physiologically bound together. If in aortic disease the left ventricle has to work harder to maintain peripheral circulation, does not the right ventricle have to work harder also to keep up general cellular oxygenation? If the right ventricle has to do more work in mitral disease, in the first place does not the right ventricular hypertrophy push the apex further to the left, and in the second place, does not the increased work of the right ventricle increase the burden on the left ventricle?

Inspection and palpation, of course, in this field go together, and it is arbitrary and pedagogical to attempt to make division between them.

In a series of patients studied at the University of Kansas Hospitals to determine the reliability of locating the apex beat by palpation, the results were checked by roentgenograms. The P. M. I. was located and a coin strapped on the chest, attempting to put the center of the coin over the apex. Normal and pathologic subjects were used. In 85 per cent of cases the error was negligible; in fact, the method was as accurate as anyone could expect. In roughly 10 per cent of cases the error was noteworthy as in an hypertrophied heart in an obese subject where we located the P. M. I. from 1 to 2 cm. inside the left border of the heart (apex). In about 2 per cent of cases the heart was not hypertrophied, but thickness of the chest wall, emphysema, or deformity caused error. In about 3 per cent of cases the error was in locating the P. M. I. outside the apex by 1 or 2 cm. on account of a thin chest wall with a small dropped heart that made an impulse so diffuse on the thin chest wall as to lead us into error.

The quality of the apex beat seems to me not of any significance. Much has been written in the textbooks on physical diagnosis on whether the apex beat is diffuse or localized. It seems incumbent on writers of textbooks, when they come to this point, to write a paragraph whether it means anything or not. Fortunately the student promptly forgets and disregards it. I cannot see that any conclusion of the slightest consequence can be drawn from determining whether an apex is diffuse or localized—a tap or a "slow vigorous

III. PERCUSSION

In my routine examination of the cardiovascular system I have put down as the only procedure involving percussion—"Percussion of the first and second interspaces on each side of the manubrium." Even this can be omitted, as it is only designed to catch an aneurysm before the x-ray technician has his triumph, and even the aneurysm can better be seen than percussed.

I do not believe there is anything to be gained from percussion of the heart.

Dr. Samuel Lambert had a method which you may try if you wish, of auscultatory percussion of the heart. He places the bell of the stethoscope over the mid-precordium (the part of the chest wall where the heart is completely exposed) and then with his fingernail gently scratches toward it from points that form a semicircle around the stethoscope bell. When the sound of the scratch changes from a far away to a sharp sound, the border line of the heart is denoted. In Dr. Lambert's hands this is very accurate.

But actually, anatomically, the cards are all stacked against you when you attempt to percuss the heart. You say you will now percuss out the right border of the heart. Consider the terrain you are going over. Your fingers lie across the ribs, not parallel with them, as would be natural. Soon you move from ribs and muscle to sternum. What do you approach anyway? The dullness will consist of the right auricle, part of the right ventricle, part of the left ventricle, the mediastinum, with all of its vessels and lymphatics. Suppose you are to percuss out the left border from above. Between the chest wall and the heart border, there is a layer of lung tissue, usually more than 5 cm. thick, and it is a fundamental principle of acoustics that we cannot demonstrate solidity that lies more than 5 cm. below overlying lung tissue.

Percussion should always be attempted in the third left interspace, as this may be the only portion of the heart enlarged to physical examination as in mitral stenosis and congenital heart disease.

Percussion in the second left interspace is decidedly unsatisfactory due to the depth of the underlying structures, particularly the descending aorta.

The late Dr. Gordon of Exeter, who prided himself on his percussion, made a special study of this subject and found that in a majority of cases his percussed outline agreed with the x-ray if the patient was standing, but not in recumbency.

"In 1923 I travelled with three cardiologists who were going to attend a meeting of that very exclusive body, the Cardiac Club of Edinburgh. I ventured to say that I mistrusted percussion as a means of estimating the size of the heart, and found to my satisfaction, that two of them agreed while the third said he only trusted his own."

IV. AUSCULTATION OF THE HEART

In routine auscultation of the heart, one places the bell of the stethoscope first over the apex. This is called the mitral area, because the sounds, whether normal or pathologic, which are produced at the mitral valve are best heard here. Then the stethoscope bell is placed in the fifth interspace either immedi-

ately to the left or to the right of the sternum, called for similar reasons the tricuspid area. Then at the second interspace to the right of the sternum, called the aortic area. Then at the second interspace to the left of the sternum, called the pulmonary area. Then it is wise to move the stethoscope bell all over the precordium and even up into the vessels of the neck.

At all of these sites two sounds are heard. At the apex, under certain circumstances, a third heart sound is heard. The two sounds regularly heard have been described over and over, never better than by James Hope (*A Treatise on Diseases of the Heart and Great Vessels*, 1839).*

"When the ear or a stethoscope is applied to the praecordial region, two successive sounds, followed by an interval of silence or repose, are distinctly heard. The first, which is synchronous with the impulse, with the pulse is duller and longer, very like that produced by jerking a cord as thick as a swan quill; the second is shorter, clearer and smarter, like the flap or click of a bellow valve, or it is still more closely imitated by lightly tapping the tense knuckle of one hand held close to the ear with the soft end of the finger of the other."

From time immemorial students have been taught that the heart sounds can be onomatopoeically imitated by the syllables "lub-dub."

It would be idle and wasteful to discuss in great detail the theories that have been advanced to account for the origin of these sounds. The first sound was generally held to be due to a combination of a muscular element due to contraction of the ventricles plus the closure of the auriculoventricular valves until 1933 when William Dock published a paper (*Mode of Production of the First Heart Sound*, Arch. Int. Med. 51: No. 5, May, 1933) which described experiments conclusively proving, at least to me, that there is no muscular element in it, but that the first heart sound is entirely valvular due to suddenly putting under high tension the previously slack fibers of the auriculoventricular valves. This is the revival, to which Dr. Dock gave experimental proof, of long previously expressed theories, as witness Hope's description, quoted above.

The tautening of the auriculoventricular valves as the ventricle goes into systole is exactly imitated by "jerking a cord" and the best way to illustrate the mechanism of the first sound to students is to take out your folded pocket handkerchief or a towel and jerk it taut. Hope was not the only one to state this explanation. J. Rouanet in a thesis, Paris, 1832, wrote (quoted by Dock), "From many experiments I have learned that any membrane passing from flaccidity to tension suddenly causes a sound. . . . The auriculoventricular valves present conditions which are most favorable for the production of sound; they pass instantly from the most complete flaccidity to sudden and violent tension." G. B. Halford (*Lancet* 2: 593, 1851) performed this experiment. "The superior and inferior vena cava and the pulmonary veins at the entrance of the left auricle were tightly compressed between the fingers. The heart continued its action, the stethoscope was again applied, and neither first nor second sound was heard"—i.e., there was muscular contraction, but no

*Laennec gave a very bad description of the heart sounds.

sound. This is much like Dock's experiment which consisted of graphic recordings on the phonocardiograph-electrocardiograph of systolic contraction and sounds before and after a cord around the atrioventricular groove was tightened so as to prevent blood from entering the ventricle. Then when the ventricles were empty, there was no heart sound.

If this explanation of the first sound is true, it leaves rather up in the air the many distinctions that clinicians have been making about the changes in the first and in various functional changes in the heart muscle. Thus Crummer (*Heart Disease*, 1925): "A light shortening of the first sound left with muffling of tone quality, is suggestive of myocardial disease. For confirmation, the patient should be put through the exercise test when it will be found that the first sound is either further shortened or disappears entirely, and a systolic murmur is heard. . . . In quick acting hearts there is a shortening of systole, and a consequent rise of pitch of both first sounds [i.e., right and left—L. C.] . . . In surgical shock and certain fulminating medical conditions there is a change in the first sound with loss of tone." These statements indicate indubitably, that myocardial damage is recognizable by changes in the tone of the first sound, a view widely held and expressed by many careful clinicians. The valvular origin explanation of the first sound not entirely squeezes it out. Dock says (op. cit.), "If the valves are closed and the slackness taken up gradually before ventricular systole occurs, the intensity of the first sound is greatly diminished. The factors determining loudness of the first sound are therefore: the degree of tension in the valve when the ventricular systole occurs, and (less important) the rate of rise of intraventricular tension." This means, I take it, that the degree of tension of the valves depends somewhat on the flabbiness of the myocardium, also on the extent to which the ventricle empties, which is the same thing.

The second heart sound is due to the closure of the aortic and pulmonary valves. There is, I believe, no difference of opinion on this point.

The third heart sound was noted first by Barie in 1893 and described first by W. S. Thayer as late as 1908. That through all the intensive investigation of the heart by physical methods during the nineteenth century it remained unnoticed, is an indication of that fact that it is by no means a constant finding, either in all individuals or in the same individual at different times of his life and different states of his health. It is heard best and most constantly in young male adults with the stethoscope just above the apex when the subject is leaning a little forward and to the left. Mayer detected its presence in 65 per cent of normal persons under the age of forty-five. It occurs after the second sound—about 0.18 of a second. It is probably caused by the tension of the chordae tendineae of the mitral valves as they tauten with the filling and increased pressure in the ventricle and before the valve edges unroll in complete closure. If this is the time explanation, the appearance of the third heart sound is the cause of gallop rhythm. Gallop rhythm notably signals a failing myocardium; with a failing myocardium the ventricle never empties, always has more blood in it than normal, and the chordae tendineae are stretched and more liable to tauten.

Auscultation of the heart, like every other physical procedure, should follow a routine order, in which the examiner concentrates upon one phase of the succession of phenomena presented. As at a circus, he should notice one ring at a time, if he is going to come away with any clear-cut impressions. The order should be:

1. Rhythm.
2. Differentiation of first and second sounds.
3. Comparison of first sounds as made by left and right ventricle.
4. Comparison of second sound as made by aortic and pulmonary valves.
5. Extraneous sounds—murmurs—in systole and diastole.
6. Sounds over the vessels of the neck.
7. Response to exercise.

1. RHYTHM.—The cardiac rhythm consists of the auricular contraction, which lasts 0.1 second, the ventricular systole which lasts 0.3 second, and the diastole which lasts 0.4 second. The first sound occurs at the end of ventricular systole, lasts 0.16 second; the second sound comes 0.2 second later, lasts 0.09 second; the third sound comes 0.18 second later.

This succession produces a rhythm to the examiner's ear for which he comes to have an instinctive awareness. In musical terms Crummer stated that normally it is in 2-4 time. When it changes to 3-4 time (waltz time), we must immediately seek an explanation; 3-4 time occurs in mitral stenosis (without, necessarily, murmurs); it is *rhythmus brightigne* or gallop rhythm, and sometimes occurs in hypertrophy with flagging compensation. Usually 3-4 time indicates the interposition of the third heart sound.

Rhythm is a most important thing with which the clinician should familiarize himself. It has nothing to do with arrhythmias. Extra sounds are the principal things that modify rhythm. A long list of these extra sounds has been compiled, and I give herewith a differential table of them.

Extra heart sounds which are not murmurs are encountered with considerable frequency; usually they are perceived as a change of rhythm. A classification of them follows:

	POINT MAXIMUM INTENSITY	TIME RELATIONS	CHARACTER	REMARKS
I. Gallop Rhythms				
A. Physiologic third heart sound.	Inside apex, usually fourth or fifth inter- space.	0.12 to 0.18 second after second sound.	Usually faint, low pitched.	Cannot be distinguished from gallop except by absence of heart disease or other causes of gallop rhythm. Common in youth.
B. Presystolic (auricular systolic). --- gallop.	Inside apex, usually fourth or fifth inter- space or just to left of sternum.	0.08 to 0.14 second after beginning of P.	Usually faint, low pitched.	Usually falls just before the third sound.

Modified and rearranged from Wolferth and Margolies: Extra Heart Sounds and Frictions and Their Differential Diagnosis, The New International Clinics, Vol. I, New Series Three, 1940.

	POINT MAXIMUM INTENSITY	TIME RELATIONS	CHARACTER	REMARKS
C. Protodias- tolic gallop.	Same as pre- systolic gal- lop.	0.12 to 0.20 second after second sound.	Usually faint, low pitched.	Common in diseases or fail- ing hearts, anemia, or hypertension.
D. Summation form of gallop. (Wolferth and Margo- lis: M. Clin. North Amer- ica, 14: 897- 907, 1931.)	Same as pre- systolic gal- lop.	Usually 0.12 to 0.20 second after record sound.	Low pitched, may be faint, loud, or short murmur.	The rate usually exceeds 100 beats per minute un- less delayed conduction is present. Occurs when auricular systole falls close to preceding ven- tricular beat in patients predisposed to gallop rhythm.
E. Systolic gallop. (Thompson and Levine: New Eng- land J. Med., 213: 1021-5, 1935.)	Aortic area or apex.	Constant and about midway between first and second sound.	Medium pitch, may be loud or faint.	The aortic type is destruc- tive. The apical type must be differentiated from the midsystolic click. Rare.
II. Reduplica- tions				
A. Redupli- cated first sound.	Apex or just to left of lower part of sternum.	Interval 0.04 to 0.12 sec- ond.	Both sounds similar, al- though one may be louder than the other.	Easily differentiated by the time relations from all extra sounds except late presystolic gallop and semilunar opening click. Common in both healthy and diseased hearts.
B. Redupli- cated second sound.	Base.	Interval 0.03 to 0.11 sec- ond.	Both sounds usually simi- lar, although either may be louder or high- er pitched.	Must be differentiated from opening snap. Common in both healthy and diseased hearts.
III. Clicks				
A. Semilunar opening click.	Aortic or pul- monary area.	Synchronous the beginning of ventricu- lar ejection.	Sharp clicking or snapping.	Differentiated from redup- lication of first sound by area of maximum in- tensity. Not infrequent when the heart is over- active.
B. The open- ing snap. (Margolis and Wol- ferth: Am. Heart J. 7: No. 4, April, 1932.)	Just below mitral ring third or fourth interspace.	0.07 to 0.13 after second sound.	Sharp snap or clicking sound. Loud or faint.	Must be differentiated from reduplication of second sound. Common in mitral stenosis and pathognomic of this disease.
C. Midsystolic click. (Gal- lavardin: Lyon méd.)	Inside apex, fourth or fifth inter- space.	Between first and second sound. Often varies with respiratory phases.	Sharp snap or clicking sound.	No clinical importance. Must be differentiated from atypical systolic gallop rhythm. Fairly common. No pathologic significance.

	POINT MAXIMUM INTENSITY	TIME RELATIONS	CHARACTER	REMARKS
IV: <i>Auricular Sounds</i>	Apex.	0.08 to 0.14 second after beginning of P wave.	Low pitched.	Heard in heart block. Similar to presystolic gallop.
A. Early type (Clendinning Brit. Ass. Report on Heart Sounds, 1840.)				
B. Late type.	Third or fourth inter-space.	0.24 to 0.30 second after beginning of P wave.	Low pitched.	Heard in heart block. Mechanism not known.
V. <i>Pericardial Sounds</i>	Precordium.	Usually 0.12 to 0.20 second after second sound.	Strong vibrating sound.	Differentiated from protodiastolic gallop and physiologic third heart sound by the sharpness --from the opening snap by the longer interval after the second sound. Suggests pericardial calcification.
A. Protodiastolic pericardial vibration.				
B. Pericardial knock.	At apex to left of heart.	Inconstant. Usually systolic but may also have diastolic component.	Knocking may be very loud.	Occurs in cases with air in the pleural space. Can often be elicited after left-sided pneumothorax.
C. Pericardial frictions.	Anywhere over precordium.	Systolic and diastolic. Lagging after first and second sounds.	Crepitating, crunching, grating, creaking.	Other evidence of pericarditis, location of sound, effect of pressure on stethoscope and of breathing important.
D. Pleuropericardial.	Left border of heart.	Same as pericardial friction.	Same as pericardial friction.	Markedly influenced by respiration. Other evidences of pleurisy may be present.
VI. <i>Lung Sounds</i>	Precordial area.	Usually systolic. May have diastolic component.	Snapping or crunching. May be very loud.	May follow spontaneous pneumothorax or perirenal air injection. Resembles the pericardial knock. Rare.
A. Due to mediastinal emphysema. (Hamman: Tr. A. Am. Phys. 52: 1937.)				
B. Air and fluid in pericardium, left pleural space, or stomach, agitated by heartbeat.	Precordium, left chest, or epigastrium.	Systolic and diastolic.	Splashing sound.	Recognition of the location of the air and fluid is the important differential point.

It must be evident that a great many of these are, so far as mechanism is concerned, modifications of the same things. The only ones, it seems to me, that have significance are fetal rhythm (which does not involve an extra heart sound and therefore does not appear in this list), gallop rhythm, the reduplications, and pericardial friction rub.

Fetal rhythm consists of evenly spaced sounds having the same quality, loudness, and tone. It occurs when the myocardium is weakened and the diastolic pause shortened. It is of serious prognostic significance.

Gallop rhythm is so named because it resembles the sound of galloping hoofs—3-4 time. Bouillard mentioned it by that name, *bruit de galop*, and I am interested to find that J. Clendinning (Brit. Ass. Report on Heart Sounds, 1840) stated that auricular contraction produced a weak sound which on careful auscultation could sometimes be faintly heard in late diastole in young people. Potain (Bull. et mém. Soc. méd. d' hôp. de Paris 12: 137, 1876) gave the first full length description as follows: "The term [gallop rhythm] is marvelously adapted to the sound it designates. . . . We distinguish here three sounds, namely, the two normal sounds and an additional sound. The normal sounds show most frequently their normal characteristics without any modification. As to the abnormal sound, it is placed immediately before the first sound, preceding it sometimes by a very short space; always notably larger, however, than that which separates the two parts of a reduplicated sound. This sound is dull, much more so than the normal sound. It is a shock, a perceptible elevation, it is scarcely a sound. If one applies the ear to the chest, it affects the tactile sensation perhaps more than the auditory sense. And if one attempts to hear it with a flexible stethoscope, it lacks only a little, almost always, of disappearing completely. The place where one perceives it best is a little below the apex of the heart, somewhat towards the right."

Gallop rhythm is essentially the interposition of an extra heart sound with usually a rapid heart rate. Several varieties of gallop rhythm have been differentiated, depending on the place in the cardiac cycle where the extra sound makes its appearance. Potain divided gallop rhythm into three varieties—presystolic (late diastolic), merodiastolic, and protodiastolic (early diastolic). In all of these the extra sound appears after the second sound, and between it and the first sound. Recently Cupper and Barbillon's paper (*Nouvelles recherches sur le bruit de galop*—Arch. gén. de méd. 1: 129, 1887) has been revived and the term, systolic gallop rhythm, has been introduced. (See Thompson and Levine: Systolic Gallop Rhythm, *New England J. Med.* 213: 1021, 1935, and Wolferth and Margolies: Systolic Gallop Rhythm, *Am. Heart J.* 19: No. 2, Feb., 1940.) In systolic gallop rhythm the extra sound is between the first and second sounds. Two forms have been distinguished: in one the additional sound is best heard over the aortic area; in the other, it is best heard over the apical region. The aortic systolic gallop sound appears to originate in the aorta; it may be due to the sudden checking of the distention of the aortic wall during systole, or by impact of the aorta against surrounding structures at that instant; it has been noted particularly in aortic insufficiency, typhoid or typhoidlike fevers, tuberculosis, and hypertensive disease. The apical systolic gallop sound has not been satisfactorily explained; it may be due to the impact of the cardiac apical region against the chest wall. LeRoy and Roberts (*Am. Heart J.* 21: No. 1, Jan., 1941) have reported it in a case of aneurysm of the left ventricle.

It must be evident that what is called systolic gallop rhythm may be readily confused with other extra heart sounds—reduplication of the first heart sound and the peculiar midsystolic click described by Gallavardia (Lyon méd. 121: 409, 1913) and ascribed by him either to tugging of pleuropericardial adhesions during systole or to the pressure of the contracting heart against some emphysematous lung tissue. Nor has it usually the serious significance of the diastolic forms of gallop rhythm. The only importance of these extra heart sounds in the systolic period is that they may be mistaken for serious heart disease.

The importance of the diastolic-presystolic and protodiastolic-gallop rhythm is that they are of serious prognostic import, the sign of a weakening myocardium. They are most commonly heard in the late stages of hypertensive cardiorenal disease. "The cry of the heart for help" is the phrase which comes to the clinician's mind when he finds gallop rhythm. True, it is not always of fatal prognostic import and true, it may be found in the heart of an athlete after a severe strain, such as a long run, but this does not change the essential nature of our judgment concerning it; the athlete's heart is overburdened and will recover only because it is young and resilient.

Any explanation of the mechanical causation of gallop rhythm must include an explanation of why it is of serious import. The presystolic form is the commonest and phonocardiograph records show that it corresponds to auricular contraction. Can the auricles make a sound in contracting? I cannot conceive of such a thing and I cannot see why auricular contraction should be of serious prognostic import.

I cannot get away from the conviction that the extra sound of gallop rhythm is caused by the same mechanism as the third heart sound. True, as Major says (*Physical Diagnosis*, op. cit.), the physiologic third heart sound is not a "cry of the heart for help" which, according to Obrastzow (*Ztschr. f. klin. Med.*, 1905), gallop rhythm is. But the third heart sound is brought out by intensive exercise amounting to strain. If auricular contraction plays any role, it means that the ventricle is overdistended with blood, which would *tauten the chorda tendineae before each systole or during diastole*. The argument that the extra sound of gallop rhythm is heard late in diastole while the third heart sound is heard early in diastole, does not seem to me valid; with the ventricle overburdened with blood throughout the cardiac cycle, the chorda tendineae could tauten any time. Wolferth and Margolies (*Gallop Rhythm and the Physiological Third Heart Sound*, *Am. Heart J.* 8: 441, 1933) say, "The only available criterion for distinguishing between physiologic third heart sounds and gallop rhythm is the status of cardiac failure."

That is something of a giveaway. If gallop rhythm is the same as the third heart sound except that it appears when the heart is weakened, then why isn't it the third heart sound?

Lewis and Dock (*The Origins of Heart Sounds and Their Variation in Myocardial Disease*, *J. A. M. A.* 110: 271, Jan. 22, 1938) have diagrams which make the mechanism reasonable. If the physiologic third heart sound is due

to the tautening of the chordae tendineae of the auriculoventricular valve just before the valve leaflets themselves tauten, then it must be evident that a heart under strain, whether from excessive exercise or myocardial disease, will from the weakness of its walls never empty at all; therefore, the chordae tendineae will always be more or less on stretch in a ventricle filled with blood and will be in a position to tauten and make a sound with every ventricular contraction. Such is my conception of gallop rhythm.

The age of election of patients with gallop rhythm is 50 to 60. The underlying disease of 199 patients with gallop rhythm was hypertensive disease in 93, coronary heart disease in 55, rheumatic heart disease in 12, syphilitic heart disease in 7, cor pulmonale in 10, and the rest scattering. (Garvin: *Am. J. M. Sc.* 205: No. 6, June, 1943.)

Auscultation of the arrhythmias of the heart is in most instances merely confirmatory of palpation of the pulse. It is possible to identify most of the arrhythmias by one or both of these means without recourse to the electrocardiograph, and this is often desirable, if not necessary. With a normal rate and rhythm it is advisable to have the patient exercise and then re-examine. Levine (*Auscultation of the Heart*, *New England J. Med.* 225: No. 14, Oct. 2, 1941) relates the case of a young man who complained of palpation. On the first auscultation the pulse was 70 and regular; after exercise his pulse rate was 140, then returned to the original. This could only be accounted for by assuming that he had an auricular flutter at first of 1-4, which under examination became 1-2-, his auricles beating at 280.

Real difficulty may be experienced in differentiating auricular fibrillation from multiple extrasystoles. Both may have pulse deficit and in both the dominant rhythm may be lost. The finding that identifies auricular fibrillation is a pause not preceded by a quick beat.

Ventricular tachycardia, a rare but important arrhythmia, may be suspected on auscultation by the difference in the tone of the first sound—the result of the mechanism of the condition which is interposition of numerous extrasystoles. The extrasystoles may come so close to the regular systoles that there is no time for the auriculoventricular valves to open and shut completely, making a first sound less loud and less sharp. The decision as to whether ventricular tachycardia is present or not “may be a matter of life or death, for ventricular tachycardia generally responds favorably to quinidine therapy and is refractory or aggravated by digitalis.” (Levine, *op. cit.*)

Heart block is detected, aside from the bradycardia, by differences in the tone of the first sound in different cycles. Bundle branch block may be suspected when, in a sick patient, there is a difference in the two first sounds of the heart at the apex as compared with the end of the sternum left.

2. DIFFERENTIATION OF FIRST AND SECOND SOUNDS.—This should be done first by listening at the apex and then at the base. The second sounds are much clearer at the base. The differentiation is, of course, usually easy, but if any doubt exists, the first sound should be timed by feeling the pulse and identified in this way.

3. COMPARISON OF FIRST SOUNDS MADE BY LEFT AND RIGHT VENTRICLE by listening first at the apex and then at the end of the sternum. The late Dr. LeRoy Crummer made much of this, but although I admired most of his pronouncements, I confess I never could make much out of this. I feel that those who make these interpretations read a good deal into their findings, based on the false assumption that the first sound represents the muscular action of the ventricle. However, for what benefit it may be, I will quote Crummer:

"In routine examination of the heart, tone value of the first sound over the right ventricle is of the utmost importance. For this reason auscultation should begin by listening to the left of the sternum in the fourth interspace, adjusting the stethoscope bell so as to obtain the clearest possible sound in this region. A considerable surface of the right ventricle is in almost direct contact with the chest wall to the left of the lower sternum. We then listen with the stethoscope bell over the apex and compare the sounds. With a normal heart there is practically no difference save of intensity in the first sound as heard in these two positions. When there is a difference, we can demonstrate by carefully shifting the stethoscope bell from place to place so that the change in sound occurs exactly at the junction line of the right and left ventricles. This change is perhaps best appreciated in a case which presents 3-4 rhythm over the left ventricle."

4. COMPARISON OF SECOND SOUNDS AS MADE AT AORTIC AND PULMONARY AREAS.—The second pulmonic sound is the louder* in early life, the second aortic sound is the louder in later life.

In 90 per cent of healthy children the second pulmonic is louder than the aortic. From the tenth to the twentieth years it is louder in two-thirds of individuals; from twenty to thirty in about half, and after thirty it is louder only when mitral disease is present. After the sixtieth year, Creighton found an accentuation of the second aortic in sixty-six out of sixty-eight cases examined.

Cabot, in his textbook on physical diagnosis, wrote: "Pathological accentuation of the pulmonic second sound must mean a greater loudness of this sound than *should be expected at the age of the patient in question* and not simply a greater intensity than that of the aortic second sound." I taught this for years but no longer subscribe to its validity. I think it is sensible to suppose that one determines the relative intensity or loudness of the two sounds by comparing them, and it certainly works out in practice.

Geigel (*Lehrbuch der Herzkrankheiten*, J. F. Bergmann) states that one sound must be twice as loud as the other to be recognized as definitely accentuated. "Hence," writes Dr. J. H. Pratt (Pratt and Bushnell: *Physical Diagnosis of Diseases of the Chest*, W. B. Saunders, 1925), "the well-known observations of Creighton have little value," but I do not follow him. Of course the aortic and pulmonary sounds are never heard alone, but one sound is always mixed with the other. But in practical work these considerations do not interfere with the fact that in actual practice such differences in auscultation do occur and carry definite connotations.

*Louder, more intense, accented, whichever you like. I select "louder" as being the most comprehensible.

The pulmonic second sound is increased in intensity in mitral disease, or any obstructive disease of the lung, such as emphysema or fibroid phthisis. Accentuated second pulmonic sounds point to hypertrophy of the right ventricle.

The aortic second sound is accentuated in any condition which raises the arterial pressure, decreases the elasticity of the aortic wall, or increases the work of the left ventricle. It is a far more important sign than accentuated second pulmonic, and its recognition is of great significance diagnostically and prognostically in nephritis, hypertension, and sclerosis of the aorta. In syphilitic aortitis and aneurysm the second aortic sound may have a peculiar ringing quality which has been compared to the tabour or African drum.

Reduplication of the second sound indicates that the ventricles are not contracting exactly synchronously. Reduplication is heard normally in many children and after severe exertion. It is not considered to have any serious clinical significance.

5. ABNORMAL SOUNDS heard over the heart area are *murmurs* and the *pericardial friction rub*.

Murmurs are hissing or rumbling or rattling or murmuring noises similar to those produced by a fluid under pressure. The French name for a murmur is *bruit*, and they commonly fit such descriptive names as *bruit de râpe* (rasp) to the murmur of mitral stenosis and *bruit de soufflet* to the murmur of aortic regurgitation. Medical students instinctively try to tell of murmurs by using descriptive names—"I hear a swishing." But all this practice may lead us into error, and it is best to allow the word murmur to be a technical term for all adventitious heart sounds (except friction rub).

The mechanical causes of murmurs can be assumed by deduction from what we find at autopsy to be five:

1. Blood passing from a wide to a narrow channel.
2. Blood passing from a narrow to a wide channel.
3. Blood passing over a roughened channel or projection into the channel.
4. Two streams of blood meeting.
5. Change in viscosity of blood—hemic murmurs.

In all of these conditions save the last, the murmur is caused by setting the blood into swirls or by the vibration of the walls of the containing cavity or by both. An example of the first is mitral stenosis; of the second, aneurysm; of the third, aortitis, calcareous aorta or a dislocated valve leaflet flapping in the stream; of the fourth, mitral regurgitation and aortic regurgitation.

Corrigan (Inquiry into the causes of *bruit de soufflet* and *frémissement cataire*, *Lancet*, 1829) showed that the condition in tubes which most favored the production of murmurs was the passage of fluid from a narrow to a wider space. Kinaslo (Neue Forschungen über die Schallerzeugung in der Kreislauforganen, *Verhandl. d. phys.-med. Gesellsch. zu Würzb.* 1: 6, 1850) and Theodor Weber made extensive studies on tubes with moving fluids going through them, and there is no reason to doubt the fact that the conditions under which they imitated murmurs are exactly similar to the conditions which give rise to cardiac and vascular murmurs. A tube with a stenosis (in medical terms)

produced a murmur at the stenosis and on both sides of it. Murmurs occur more readily in thin-walled tubes, and in wide rather than narrow tubes. In straight-walled tubes the fluid must move with great velocity to produce a murmur. Murmurs are produced most easily when mercury is used as the fluid, next most readily in water, next in water and blood, least readily when blood was used. All observers agree that the vibration of the walls of the containing tube causes the murmur.

Hemic or functional murmurs cannot be so easily explained. They occur in states of anemia or poor health. They are temporary; when health or anemia improves, they cease. They are systolic in time in 99 or more per cent of cases. They are found most often in young people between the ages of twenty and thirty. Every one of these statements, however, needs some qualification. Potain found functional murmurs in practically all cases of Grave's disease, in 50 per cent of cases of chlorosis, in 25 per cent of cases of measles and scarlet fever, and 10 per cent of cases of pulmonary disease.

A natural and commonly held explanation for them is that the blood is less viscid in anemic and invalid states and that it swirls more easily, the swirls producing the murmur. The objection to such a theory is that anemia is not always found when such a "hemic" murmur is present. White (*Heart Disease*, op. cit.) explains them by saying "conditions like anemia act by causing cardiac dilatation" so that we really have a relative insufficiency of some valve. This is undoubtedly true, but does not explain the predilection of these murmurs, systolic in time, for the pulmonary area; if dilatation were the cause, there would be pulmonary regurgitation and a diastolic murmur. However, the important features to know are that in states of general poor health, murmurs appear in the heart, are of no serious significance other than the significance of the nature of the bad health which causes them, and when restoration to health occurs, they disappear.

The functional murmurs of the pulmonary area are somewhat different. It has been called the "area of romance on account of the variety of interpretations given to the murmurs having their position of maximum intensity in that position" (Balfour: *Clinical Lectures on Diseases of the Heart and Aorta*, London, 1898). Lee found a systolic murmur at this area in 70 per cent of Harvard students in the recumbent position. It is the commonest of all murmurs, really almost physiologic. "Such murmurs are probably associated with slight functional distortion of the pulmonary artery." (Major, *Physical Diagnosis*.)

Cardiorespiratory murmurs are most frequent at the apex and are produced in the lungs by the systole of the heart (rarely they are heard in diastole). The normal murmur of inspiration is broken in two, three, or more short murmurs by the heart pinching a tongue of lung against the chest wall. Pericardial friction rub occurs whenever the visceral and parietal layers of the pericardium are roughened. The movement of the heart, causing these two roughened or dry surfaces to rub over each other, causes the sound. The only three conditions which produce these roughened surfaces are (1) acute pericarditis in the fibrinous stage; (2) infarction of the wall of the myocar-

dium following coronary thrombosis, presenting a localized roughened area (pericarditis brightigne of the French), and (3) very rarely tumors of the pericardium. Callin (*Les diverses methodes d'exploration de la Poitrine*, 1824), who first described the sign, said it is a "sound analogous to the creaking of new leather. It occurred in a patient who died of chronic pericarditis. This sound continued in the first six days of the disease, but disappeared as soon as the local symptoms indicated a slight liquid effusion into the pericardium."

Pericardial friction rub which is naturally systolic and diastolic, is unaffected by respiration; this differentiates it from pleural friction which it resembles. Another diagnostic point is that it is strictly localized; if you find it and move your stethoscope even as much as an inch, you may lose it.

Pericardial friction is seldom found except when, for cause, it is searched for. It is probably the most constantly overlooked physical sign. But fortunately this does not affect prognosis or treatment.

For the interpretation of a murmur, note:

1. **The time of the murmur in the cardiac cycle**—systolic, diastolic, presystolic, or double (both diastolic and systolic), or continuous—is decided by auscultation over the murmur area and simultaneously feeling the pulse. The examiner should not depend upon his judgment of the quality of sound as to which is the first and which the second sound of the heart, because these may be so changed by the murmurs as to confuse recognition. The pulse beat, however, certainly marks the height of systole, and must be used as the guide. The radial pulse, the carotid pulse or the apex beat itself can be used. There is usually room at the apex for the palpating finger and the stethoscope at the same time. Dr. W. S. Thayer's practice was to put his finger on the apex and the stethoscope on top of it. If, for any reason, palpation of the apex beat is impossible, use the carotid artery, and last in preference, the radial. The time between the apex beat and the radial beat is only about a fifth of a second, so in most cases no confusion will result from using it as a guide.

2. **The Point of Maximum Loudness of the Murmur.**—As a result of comparing the findings during life with autopsy findings, it can be said that an organic murmur heard loudest at the apex is due to disease of the mitral valve, at the end of the sternum to the tricuspid valve, at the second right costal interspace to disease either of the aortic valve or of the aorta itself, at the second left costal interspace to disease of the pulmonary valve or dilatation of the pulmonary artery or to congenital heart disease. There are some exceptions. Aortic regurgitant (diastolic) murmurs are often heard loudest at the third left interspace close to the sternum. The Austin Flint and Graham Steell murmurs are exceptions but can be explained logically.

Timing of murmurs can be done very accurately after a little experience, but location may tax every resource of the diagnostician.

The diastolic aortic murmur and the presystolic mitral murmur are, in most instances, sharply localized, so that the determination of their location is usually possible. I emphasize the word *usually*; exceptions occur. But

systolic murmurs, whether mitral or aortic, are often so diffuse that the localization has to be made by inference. In a young person, with a history of rheumatism and other evidences of mitral disease, such as accentuated second pulmonic, a diffuse systolic murmur will be identified as mitral. In an elderly arteriosclerotic patient, a diffuse systolic murmur will be suspected to be of aortic origin.

Mitral systolic murmurs classically are transmitted around the chest into the axilla and back. Aortic systolic murmurs classically are transmitted up the neck along the carotids and into the shoulder. But patients present themselves with murmurs heard almost equally all over the precordium. Twenty-five per cent of patients with atheromatous aortic degeneration, in which the calcification and ulceration of the aorta must have been the cause of the murmur, present in life a systolic murmur, heard loudest in the mitral and tricuspid regions.

The examiner, by moving his stethoscope centimeter by centimeter over the precordium, along the pathways from the mitral to the aortic areas will, however, even in puzzling cases, usually be able to decide the point of maximum intensity.

3. The Character of the Murmur.—While it is true that the experienced examiner can often recognize the rolling, rattling grind of mitral stenosis, or the low, sighing murmur of aortic regurgitation, or the harsh, swishing noise produced by systolic murmurs, and differentiate them from each other by their characteristic sound alone, it is never safe to do so, and the beginner in physical diagnosis should depend strictly on diagnosis by time and location of murmurs.

The French school in the early days after the introduction of the stethoscope, attempted to attach imitative names or murmurs in order to characterize them. Thus Bertin, probably the first to describe the murmur of mitral stenosis (1824), did so as "a distinct sound, which resembles the sound of a file on wood." But he also said it is heard "during the contraction of the auricles," that is, he also timed it.

Fauvel (1843) said, "In the precordial region besides a forceful impulse and a considerable area of dullness, one heard an intense rasping murmur, *bruit de rape**—preceding the first sound, finishing with it, having its maximum intensity at the apex of the heart and to the left." Notice he was not satisfied with describing it; he also located the maximum intensity and the time.

The same obtains for Hope's description (1831) of the murmur of aortic insufficiency. "When there is regurgitation through the permanently open aortic valves, a murmur accompanies the second sound, . . . louder and more superficial opposite to and above the aortic valves than above the apex of the heart . . . the softness of a mellow murmur, like whispering the word *awe* during inspiration."

Compare also Corrigan's description of the same murmur (1832), "The *bruit de soufflet*† characterizing this disease is heard in the ascending aorta,

**Rape*—rasp.

†*Soufflet*—bellows.

carotids and subclavians and is synchronous with the visible pulsation, the diastole of the arteries—the impression made distinctly on the ear is from a rushing back of it into the ventricle. It is impossible for those who have not heard this double bruit to conceive the distinctness with which the impression is made on the ear. A patient in one instance heard the double sound distinctly in his own person and referred it to its cause, a rushing of blood from and to the heart.”

Presuming that organic valvular disease is present, with the time and the place of the murmur accurately decided, the determination of the nature of the murmur is merely a matter of logic. A systolic murmur at the mitral area must be mitral regurgitation (whether it is regurgitation and stenosis combined is beside the present point), a diastolic murmur in the aortic area must be aortic regurgitation, etc. There are some exceptions, as in the case of a systolic murmur in the aortic area—logically, it should be aortic stenosis; as a matter of experience, it is usually an atheromatous aorta.

4. **Accessory Signs.**—Conclusions drawn from murmurs alone are notoriously deceptive. I have been careful to write “*organic*” valvular disease when describing the method of determining the origin of these murmurs. Thus you must determine functional from organic disease. In deciding this, consider that any derangement of the working of the heart valves lasting over a period of time of some length will put extra work on the heart muscle and result in hypertrophy. Disease of the mitral valve will raise pressure in the left auricle and cause accentuation of the second pulmonic valve sound. So to establish mitral disease three signs, (1) displacement of the apex beat to the left, (2) accentuated second pulmonic, and (3) apical murmur, must be present, and all three are necessary for a diagnosis. (In very early cases before there has been time for hypertrophy, murmur may be present alone, but this is more theoretical than practical.) Also in aortic regurgitation the pulse signs—Corrigan pulse, leaping carotids, and brachials and capillary pulse—are just as important as the murmur.

Most functional murmurs are systolic.

5. **Accentuation Maneuvers.**—It is the hallmark of an accomplished diagnostician when examining the heart to ask the patient to hop up and down twenty times and then auscult. This brings out many murmurs, especially mitral murmurs, that would not be audible during the quiet systole of the heart.

Clinical Features of Endocardial Murmurs

Bacterial Endocarditis.—Acute bacterial endocarditis may occur in the course of any infection. *Staphylococcus aureus* and *streptococcus hemolyticus* have been found on the vegetations. Congenital hearts make a particularly good soil for the implantation of a terminal endocarditis. The disease is essentially a septicemia with the point of infection of the blood stream, the infective vegetations in the endocardium and valves. It runs a malignant course—four to eight weeks. Diagnosis is made by the presence of an other-

wise unexplained fever, positive blood culture, petechiae, chills, vagrant cardiac murmurs, and possibly a leucocytosis, although a leucopenia is often encountered.

Subacute bacterial endocarditis is more common than the acute form, but like it is more a bacteremia than a cardiac disease. The conditions for its development are a previously damaged endocardium and an acute infection. One out of every twenty-five cases of rheumatic heart disease develops subacute bacterial endocarditis (White). Congenital heart disease, as in the acute form, also provides good soil. The acute infective agent is the *streptococcus viridans* or other nonhemolytic streptococcus in 95 per cent of all cases. *Streptococcus salivarius* gives a somewhat better prognosis. Enterococcal endocarditis due to organisms inhabiting the intestinal tract is described (Skinner and Edwards: New England J. Med. 226: No. 1, Jan. 1, 1942). The causative agent does not greatly change the clinical picture. The diagnosis is easy, provided the possibility of the disease occurs to the clinician when he is confronted with an unexplained fever of some duration. Blood culture is the clinching point in diagnosis. Secondary anemia with a *café au lait* pallor, vagrant heart murmurs, chills, splenomegaly, clubbing of the fingers, and petechiae are the other signs.

Petechiae are superficial erythematous or hemorrhagic spots, appearing under the skin, toe- or fingernails, or in the conjunctiva. Osler says he never saw them hemorrhagic, but always erythematous, but this surely is not the common experience. They were described by Dr. Mullen of Hamilton in Dr. Osler's classic paper (Quart. J. Med., 1909) as follows:

"The spots came out at intervals as small swollen areas, some the size of a pea, others a centimeter and a half in diameter, raised red with a whitish spot in the center. I have known them to pass away in a few hours, but more commonly they last for a day, or even longer. The commonest situation is near the tip of the finger, and may be slightly swollen." Petechiae are not emboli, but the site of the location of some of the invading organisms in a capillary tuft. Nothing is more certainly the mark of the able clinician than the care with which he searches for petechiae in the suspected case.

The course of subacute bacterial endocarditis is insidious in onset, with gradually failing health for weeks or months. The average duration is six months; the extremes, a few weeks or a year or more.

Prognosis, in my experience, depends upon whether there are petechiae or not. With petechiae, the outcome is always fatal. But I have seen cases with positive blood cultures without petechiae get well.

Gonococcic Endocarditis.—Thayer (Tr. A. Am. Physicians 37: 248, 1922) found out of 176 cases of acute endocarditis, that 20 (11.3 per cent) were gonococcic. Arthritis accompanied from 40 to 60 per cent of cases. When vegetations occur, the aortic and pulmonary valves are the ones commonly affected.

Pneumococcic endocarditis is a rare complication of pneumonia. If endocarditis occurs during the course of a pneumonia, it proves to be due to the pneumococcus in all but about a quarter of the cases. It may occur during

the acute stage or weeks or months afterwards. The diagnosis is obscured by the pneumonia, the bacteriemia, and the meningitis, the last nearly a constant accompaniment. It affects the mitral or aortic valves in most cases, produces murmurs in about half the cases; petechiae or enlarged spleen is seldom found. Blood culture is usually positive. (Rueggsegger: *Pneumococcic Endocarditis*, Arch. Int. Med. 62: No. 3, Sept., 1938.)

Verrucous Endocarditis, Libman-Sacks' disease (Arch. Int. Med. 33: 701, 1924).—This is a valvular endocarditis in which all four valves and adjacent mural endocardium are involved with prominent verrucous vegetations. It is of unknown etiology—not rheumatic or streptococcic; in fact, no organisms have ever been cultured. It runs a subacute course with fever and progressive anemia. Associated clinical findings are pericarditis, white-centered petechiae, arthritis, erythematous and purpuric rashes, ulcerative lesions of the mucous membrane, pleuropulmonary symptoms, embolic phenomena, enlargement of the liver and spleen, acute glomerulonephritis, leucopenia, and repeatedly negative blood cultures. Its resemblance to disseminated lupus erythematosus leads to the suggestion that it is the endocardial form of that disease.

Mitral Valve Disease

MITRAL STENOSIS—MITRAL REGURGITATION

Pure mitral stenosis alone occurred 107 times, mitral and aortic disease 38 times, pure mitral regurgitation 7 times (pure aortic regurgitation alone of rheumatic origin, 13 times) in 4,000 autopsies, the figures of which were gathered by Cabot from 1896 to 1919 (*Facts on the Heart*, op. cit.).

Mitral disease is, in the vast majority of cases, of rheumatic origin. It is never, so far as I can gather, of syphilitic origin. Bacterial endocarditis, of course, produces soft vegetations on the mitral valve, and there are cases of semicalcareous or sclerotic mitral involvement due to arterial degenerative disease: they are always regurgitation; it is the only explanation that accounts for certain systolic murmurs found in the middle-aged and evidently of recent origin.

"Over one-half the cases of mitral disease were not recognized during life." (Cabot.)

Mitral disease is a progressive process. It begins in childhood or youth (rarely after thirty) following an attack or attacks of rheumatic fever. By rheumatic fever I mean, to quote Cabot again, a general septicemia, point of entrance unknown, which may settle in the joints in the subcutaneous tissues (nodules), in the nervous system (chorea), or in the tonsils, and may be implanted in the pericardium, the myocardium, or in the heart valves without any other localization. The pericarditis and myocarditis have been described elsewhere.

If all the phenomena of mitral disease happened to one person, the following would be the progression of events:

1. Slight stiffness of the mitral valves preventing their complete closure in systole—soft systolic murmur of convalescence, without hypertrophy or

accentuation of second pulmonic. (Complete resolution and recovery from this stage may occur.)

2. Progressive stiffness of the mitral, not enough to produce stenosis, but will allow mitral regurgitation. Beginning hypertrophy—systolic apical murmur, movement of P. M. I. to left, accentuated second pulmonic. This stage may go on for years so that there is some stenosis, but the dominant lesion is regurgitation and the only auscultatory sign is the systolic murmur. Of course, this stage may not occur at all, and the only murmur ever found will be the presystolic apical.

3. The imposition of definite mitral stenosis—with the appearance of the presystolic murmur—the “crescendo murmur ending in a snapping first sound.” Theoretically the sign preceding the murmur should be the opening snap, the *claquement mitrale*. And certainly we see enough of such cases, with the opening snap or loud first sound alone heard at rest, and the presystolic murmur brought out on exertion to make it not very theoretical.

4. Continuing hypertrophy and rise of pulmonary pressure without louder second pulmonic, presystolic apical thrill. Period of compensation: may last years. The diastolic pulmonic murmur of Graham Steell may be present.

5. Progression of stenosis with lengthening of the murmur back into the time of diastole. This prolongation backward of the murmur is due to the fact that it required all of diastole to get the blood from the auricle to the ventricle, and in order to do so the ventricle must exert a sucking action.

6. Auricular Fibrillation.—Irregular pulse. Congestive failure. Disappearance of the presystolic murmur and thrill because the auricle no longer contracts to produce them. If the murmur persists, we must lay it to the sucking action of the ventricle. Hoarseness and aphonia have been reported due to pressure of the auricle on the recurrent laryngeal nerve. (White and Garland: Arch. Int. Med. 26: 343, Sept., 1920.)

7. Relative tricuspid regurgitation with a systolic murmur at the tricuspid area. Pulsating liver is a possibility following this, but is of extreme rarity.

8. Embolic Phenomena.—The relative frequency of emboli is approximately:

Pulmonary	9	Kidney	1
Leg or arm	7	Mesentery	1
Cerebral	2	Spleen	1

The frequency of pulmonary embolism is hard to account for with a left-sided lesion, but it must be assumed that with fibrillation and resulting stasis, clots are formed in the right heart. Pulmonary infarction is recognized in one-third of cases during life, mainly by the occurrence of a hemoptysis. The symptom of pain in the chest may be volunteered (it is not severe) or it may be elicited. Over the infarcted area, provided it is close enough to the surface of the lung, sticky râles are heard. Renal infarction produces pain in the hypochondrium, albuminuria, but not hematuria with any regularity and only when the infarct is fresh. Splenic infarction is occasionally diagnosed by the occurrence of a sudden sharp pain in the presence of a decompensated heart.

Harris and Levine (Cerebral Embolism in Mitral Stenosis, *Ann. Int. Med.* 15: No. 4, Oct., 1941) found out of seventy-two cases of mitral stenosis with cerebral embolism there was associated hypertension in eighteen cases, auricular fibrillation was present in fifty-five cases, regular rhythm in seventeen, congestive heart failure in twenty-three cases, and immediate fatalities in twenty-four cases. Hines and Hunt (Pulmonary Infarction in Heart Disease, *Ann. Int. Med.* 15: No. 4, Oct., 1941) found that in 101 cases of pulmonary infarction in 1,311 necropsies, rheumatic heart disease caused it in 36 per cent of cases, hypertensive disease in 30 per cent. The symptoms of pulmonary infarction in order of frequency was: dyspnea (95 per cent), cough (54 per cent), precordial pain (42 per cent), hemoptysis (8 per cent), asthma (6 per cent).

In advanced mitral stenosis with fibrillation the chances of intracardiac thrombosis are one in four (Cabot). This is what makes the use of quinidine so dangerous in mitral stenosis with fibrillation; to stir up the auricle to contraction is to run the risk of detaching a clot. In 90 per cent of intracardiac thrombosis in mitral disease, the thrombus is in the left auricle.

Ball Valve Thrombus Phenomenon.—A ball thrombus is a round, hard thrombus unattached to the heart wall. Only thirty-two cases have been reported up to 1941. See Aronstein and Newman: *Arch. Path.* 27: No. 5, May, 1939, and Kleiber: *Ann. Int. Med.* 15: No. 5, 1941) only four of which have been diagnosed antemortem. All are associated with mitral stenosis and in all but one case, the thrombus was in the left auricle. French (*Guy's Hosp. Rep.* 66: 353, 1912) reported a thrombus in the right auricle. The mechanism of production of a ball valve thrombus is quite clear: with a conical stenosed mitral orifice with the truncated cone pointing toward the ventricle, a thrombus will be rolled around, alternately engaged in the orifice and then passed back until it is molded into a globular shape. In the Liverpool Museum is a specimen called the golf ball heart.

"Never has a case of ball-thrombus or loose thrombus been diagnosed save in the post mortem room," wrote Hewitt (*Johns Hopkins Hosp. Rep.* (17: 80, 1916), but this has been disproved. Abramson (*Ann. Clin. Med.* 3: 327, 1924) in a long, interesting critical review states: "In the presence of signs of mitral stenosis associated with severe disturbance of the general circulation, extreme feebleness of the pulse, and the presence of gangrene or cadaveric coldness of the lower extremities, suspicion of thrombosis of the left auricle should be entertained." Cerebral embolism is common in all reported cases, though of course not specific. Kleiber reported brassy cough, probably due to pressure of the auricle on the recurrent laryngeal nerve. Attacks of syncope and pulselessness occur when the thrombus blocks the auriculoventricular opening. The gangrenous and cadaveric or mottled condition of the skin of the extremities is regularly reported. Circumscribed areas of gangrene, "rose-violaceous ulcers on the feet," cyanosis of the extremities, and mottling of the skin make up the content of the descriptions. Lutenbacher's case (*Arch. d. mal. du coeur* 10: 353, 1917) had an infarct of the nose with development of gangrene.

9. Death occurs in mitral stenosis from passive congestion 50 per cent, noncardiac disease (cancer, etc.) 33 per cent, embolism 10 per cent, sepsis 6 per cent, sudden unexplained 1 per cent.

White and Bland (J. A. M. A. 116: No. 18, May 3, 1941) reported four patients with mitral stenosis who lived to be over eighty years of age. Seventy per cent of patients, however, die before the age of fifty.

This view of the progressive nature of mitral stenosis explains many points that are in debate. It explains, I think, the argument advanced by Dr. William D. Reid (The True and False Presystolic Murmurs, J. A. M. A. 82: 1040, March 29, 1924) that "the crescendo murmur ending in a sharp first sound is in reality early systolic." If there is any degree of mitral regurgitation, the murmur will be systolic. It explains the statements that the murmur is really diastolic or as Major (*Physical Diagnosis*, op. cit.) says: "In addition to this short presystolic or late diastolic murmur, there is also commonly present an early diastolic murmur which follows closely on the second heart sound and commonly lasts through the greater part of diastole. This murmur is the well-known diastolic murmur which often persists in auricular fibrillation, while the presystolic, ending in a sharp first sound, is in reality early systolic."

If this is really true, the systolic part of the murmur is due to the associated regurgitation. It explains why, on the total contrary the murmur of mitral stenosis is said to be really middiastolic.

It is a question whether the stenosis is advanced enough to require the sucking action of the ventricle to get the blood from auricle to ventricle.

C. J. B. Williams (*Diseases of the Chest*, ed. 3, London, 1835) wrote: "Mitral Valve.—Obstruction of this valve may cause a murmur with diastole of the ventricle and therefore at the time of the second sound, for although the ventricle in itself produces no sound, yet, when the orifice by which it becomes repelled is contracted, the current being partially resisted in passing through may become sonorous."

This is the basis for White's emphasized statement: "The auscultatory proof of mitral stenosis is the presence of a rumbling apical middiastolic murmur, with or without presystolic accentuation." It explains why pure mitral regurgitation is considered to be so rare. Mitral regurgitation is a stage in the development of mitral stenosis, and the diagnosis of mitral stenosis or better, mitral valve disease can be made on the systolic murmur.

One or two points need some elaboration:

The opening mitral snap, *claquement d'ouverture de la mitrale*, may be the only auscultatory sign of mitral stenosis.) It may, of course, be present along with the presystolic murmur. Duroziez (Arch. gén. de méd. 20: 385, 1862) first described it, but he ascribed it to asynchronism of aortic and pulmonic valves. Guttman (Lehrbuch der klinischen Untersuchung Methoden, 1872) first recognized that it is not due to reduplication at the base. Sansoni (Proc. Med. Soc. London 5: 191, 1881) stated that the cause is tension on the mitral

curtains. Margolies and Wolferth (Am. Heart J. 7, No. 4, Apr., 1932) studied the phenomenon by careful methods of sound registration and came to the following conclusions:

"1. The opening snap (*claquement d'ouverture de la mitrale*) can be heard and recorded in more than half the cases of mitral stenosis. It has not been observed in the absence of mitral stenosis. It is one of the most important diagnostic signs of this valvular lesion.

"2. The chief characteristics of the opening snap are the following: (a) The sound is a sharp snap or click. (b) It has been found to occur from 0.03 to 0.19 second after the beginning of the second sound, the ordinary range being 0.06 to 0.11 second. (c) It is usually loudest in the fourth left inter-space, occasionally in the third, slightly above and to the right of the area in which the diastolic murmur is best heard. (d) It precedes the onset of the murmur by a short interval. (e) It is usually best elicited with the patient in the recumbent position. (f) In some cases it can be brought out by exercise and by increase of the cardiac rate. (g) It tends to be louder when the rate is rapid.

"3. The interval between the second heart sound and the opening snap is influenced by the cardiac rate, tending to become shorter as the rate increases. Variations in the duration of this interval occur during auricular fibrillation and sinus arrhythmia depending on the length of the preceding heart cycle.

"4. The opening snap is easily differentiated from reduplication of the second sound protodiastolic gallop sounds, the physiological third heart sound and systolic clicking sounds.

"5. The time relations of the opening snap, as observed from comparisons of sound tracings with electrocardiograms, apex cardiograms, jugular phlebograms, auricular and ventricular roentgen kymograms, exclude auricular contraction, ventricular rotation or filling, or shock-like waves transmitted from the aortic to the mitral valve, as factors in its production. All the evidence thus far available is in accord with the hypothesis that the sound is produced by the sudden limitation of the opening movement of a stenosed mitral valve which occurs in early diastole as soon as the left ventricle relaxes sufficiently to permit the pressure of the auricular blood column to become effective."

The Graham Steell Murmur.—Graham Steell (The Murmur of High Pressure in the Pulmonary Artery, Med. Chron. 9: 182, Dec., 1888) described the early blowing diastolic murmur heard along the left border of the sternum due to functional regurgitation through the pulmonic valve. The pulmonic valve itself is not diseased: its apposition is prevented by stretching of its ring of attachment from high pressure in the pulmonary circulation. Usually when the Graham Steell murmur is diagnosed during life, aortic regurgitation is found post mortem, but while rare, it does not exist as an entity (see White: The Graham Steell Murmur, J. A. M. A. 90: 603, Feb. 25, 1928).

The differential diagnosis of mitral stenosis is not complicated. To the alert clinician, familiar with the ins and outs of the disease, there are few conditions with which it can be mistaken. The Austin Flint murmur in aortic regurgitation is possibly one of these. Dr. Maude Abbott once criticized to me a clinic in which I had presented a case of mitral stenosis, because I did mention the possibility of a patent foramen ovale and sent me a reprint (Abbott: Two Cases of Widely Patent Foramen Ovale. The Internat. Assn. Med. Mus. Bull.

No. 5, June 1, 1915). When the rheumatic disease has affected the pericardium and/or aortic valve at the same time as the mitral, the complication may present a puzzling picture.

Mitral regurgitation alone must be quite rare. Cabot called it "that great rarity" and could find only seven cases in his series of 4,000 cardiac necropsies. Yet the diagnosis of mitral regurgitation is made more commonly than of any other valvular lesion. This is due to making the diagnosis under the following conditions:

(1) When mitral regurgitation exists as a stage in the progress of mitral stenosis. (2) Loud apical murmurs are very common. Roger T. Lee found that 70 per cent of normal unselected individuals had a systolic apical murmur in the recumbent position after strong exertion. This is of great importance in examining candidates for an industrial position or for the army. (3) In elderly people a systolic apical murmur is often heard, possibly transmitted from the base or due to calcification and slight thickening of the mitral leaflets.

The other signs of mitral regurgitation are P. M. I. displaced to left, apical systolic murmur, and accentuation of second pulmonic.

Tricuspid stenosis is of extreme rarity, about 300 cases being reported with successful ante-mortem diagnosis made in about 10 per cent. The etiology is probably rheumatism, possibly congenital defect, although authors avoid the subject. In Smith and Levine's series (Am. Heart J. 23: No. 6, June, 1942) there was always associated mitral stenosis and in 75 per cent there was associated aortic stenosis. The most important signs and symptoms are: Dyspnea on exertion, discoloration of the skin with a peculiar combination of cyanosis and subicteric tint, great dilatation of the right auricle (seen on x-ray examination), distention of the cervical veins, marked enlargement of the liver with positive presystolic liver pulsation, a rough diastolic and presystolic murmur at the xiphoid end of the sternum. For successful diagnosis the murmur must be distinct from apical presystolic murmur: in Zeisler's case it is stated that while mitral stenosis was also present, there was an area of silence between the two murmurs. (See Zeisler: Am. Heart J. 8, No. 6, 1933, and Friedlander and Kerr: Am. Heart J. 11: 357, 1936.)

In diagnosis the associated signs of dyspnea on exertion out of all proportion to the amount one might expect in compensated mitral stenosis and cyanosis which persists even when there is full compensation are quite as important as the pulse signs in the diagnosis of aortic regurgitation.

Tricuspid Regurgitation.—

(1) Relative tricuspid insufficiency, more or less transient, is very common in congestive heart failure. It has been mentioned above as one of the events likely to occur during the progression of mitral disease. When the venous pressure in the pulmonary circulation rises, it reflects on the right ventricle and dilatation ensues; the dilating ventricle includes the tricuspid sphincter and pulls the tricuspid leaflets apart. Krehl thought that besides the relaxation of the tricuspid sphincter the dilated chamber pulled the origins

of the chordae tendineae so that they were too short to permit perfect valvular closure. Mackenzie thought that under ordinary conditions the tricuspid leaflets were barely able to close the orifice perfectly and that the slightest disturbance would cause leakage.

A contrary view is expressed by Wiggers, who states that the right ventricle can be distended under great pressure to the amount of 200 to 250 mm of water without producing regurgitation.

(2) Organic tricuspid regurgitation is very rare. Norris says it is commoner than supposed. Just how rare or common, I cannot state. After a diligent search of the literature, I find no references to any actual case observed. It may be associated with patency of the interventricular septum. The signs are the same as in the relative form: a systolic murmur at the tricuspid area with pulsating jugulars, enlarged and pulsating liver. Sensenbach and Hutaff (*Am. Heart J.* 25: 539, No. 4, April, 1943) report a remarkable case of relative tricuspid insufficiency in which large varicose veins in the legs pulsated and over which a thrill was felt.

Pulmonary stenosis is under all circumstances a rare lesion. The commonest form is in association with congenital heart deformity (tetralogy of Fallot) and is considered below under that heading. The acquired form may be rheumatic or due to the vegetations of bacterial endocarditis. Pulmonary tuberculosis is associated with pulmonary stenosis in nearly one-third of all cases. Doniger (*J. Path. and Bact.* 48: No. 2, March, 1939) reported a case of pulmonary stenosis from severe atheroma found at autopsy in a man, sixty-four, who died of carcinoma of the head of the pancreas. It was not recognized during life. There was no reason to suspect a congenital factor.

In the acquired form the signs are a harsh systolic murmur accompanied by thrill in the pulmonary area, and right ventricular hypertrophy. Clubbing of the fingers and cyanosis are rare in the acquired form.

Pulmonary insufficiency may be relative as in relaxation of the pulmonary ring in mitral disease from high pressure in the pulmonary circulation with production of the Graham Steell murmur, or acquired. The acquired form is very rare: Kissin (*Am. Heart J.* 12: No. 2, Aug., 1936) in 1936 gathered reports of 151 cases from the literature, and added three of Maude Abbott's and one of his own with four pulmonary cusps.

In 24,000 medical admissions at Johns Hopkins Hospital, Hirschfelder recorded three cases. The infection in pulmonary insufficiency is most often the gonococcus (Thayer: *Gonorrheal Endocarditis*, Tr. A. *Am. Physicians* 37: 248, 1922). McGuire and McNamara (*Am. Heart J.* 14: 562, Nov., 1937) found the pulmonary valve involved in 14 out of 30 cases of rheumatic heart disease. Allyn quotes Pitt (*Am. J. M. Sc.* 146: 541, 1913) as saying that 60 out of 109 cases of pulmonary insufficiency were caused by acute bacterial endocarditis (gonococcus 6, streptococcus 2, staphylococcus 4, pneumococcus 1). Syphilis of the pulmonary artery, though rare (Karsner in 1933 gathered only eleven cases), will cause it.

The signs are diastolic murmur at the second left costal cartilage, transmitted down the left border of the sternum, enlargement of the right ventricle, marked pulsation in the second and third interspaces to the left of the sternum and jugular pulsation. Cyanosis may be present. On the x-ray prominence of the pulmonary conus is a requisite finding for diagnosis. There is right axis deviation of the electrocardiogram.

Combined Valve Lesions.—Double disease of one valve, stenosis and regurgitation, or disease of two valves is at least as common as a single lesion. Pratt writes: "The diagnosis is complicated in about 50 per cent of cases seen clinically by the existence of more than one valvular lesion"; but when one considers how common double disease of the mitral valve is, and the occurrence of relative insufficiencies of the tricuspid and pulmonary valves, the proportion is probably higher than that.

The most frequent combinations in order of frequency are:

Mitral stenosis and regurgitation.

Mitral stenosis and relative pulmonary regurgitation.

Mitral stenosis and relative tricuspid regurgitation.

Rheumatic mitral and aortic disease. (Mitral stenosis and aortic regurgitation.)

Syphilitic aortic regurgitation and stenosis.

Aortic Valve Disease

Aortic Regurgitation.—Aortic regurgitation is of syphilitic origin in about 90 per cent of cases; 10 per cent of rheumatic origin. Cabot's figures show four rheumatic aortic valve lesions out of ninety-four cases. Rheumatism usually produces both aortic regurgitation and stenosis. Syphilis produces pure regurgitation and stenosis. Syphilis produces pure regurgitation. Cabot indicated that this is always so. He wrote: "Syphilis produces pure aortic regurgitation while endocarditis produces stenosis and regurgitation at the aortic valve." (*Facts on the Heart*, p. 253.) (I am unable, from my own material, either to affirm or deny this. Cabot found one case in his series of aortic regurgitation due to atheromatous disease.)

Syphilitic aortic regurgitation is like rheumatic mitral disease, a progressive disease. Rheumatic aortic disease is, in my experience, not noticeably progressive. We must theoretically assume that in all cases of syphilitic aortic regurgitation, the lesion begins in the ascending aorta and works backward toward the valvular orifice. The incompetency of the valves therefore is preceded by syphilitic aortitis which produces, or should produce, the characteristic signs. Syphilitic aortitis may, however, produce no signs or symptoms at all. Substernal discomfort and paroxysmal dyspnea may be present.

The elongation and dilatation of the aorta may produce pulsation palpable in the suprasternal notch. The carotids may show an exaggerated pulse wave, receding quickly on account of the inelastic aorta. Parasternal dullness may be increased, due to the widened aorta. The inequalities of the aortic intima may produce a systolic murmur. Probably the most characteristic and con-

stant of the signs is the peculiar quality of the second aortic sound—the tabour or African drum sound exactly describes it—a booming or amphoric quality. The x-ray film should give evidence of dilatation of the aorta, but in the early cases it is disappointing. Left ventricular hypertrophy is not characteristic at this stage.

When the aortic valves or ring become involved and regurgitation sets in, the signs are so invariable and characteristic that any sophomore medical student should immediately recognize them. They are:

1. P. M. I. or apex outside midclavicular line to anterior axillary or even midaxillary line, the sign of left ventricular hypertrophy.

2. The diastolic murmur heard in the aortic area, or really best at the left border of the sternum at the third or fourth interspaces. The blood flows back past the incompetent valves into the ventricle in diastole and meets the column of blood coming down from the auricle, producing this murmur. It is soft and low pitched, imitated by whispering the word *awe*.

3. Disappearance of the second aortic sound.

4. Pulse signs—leaping brachials, carotids and temporals, Corrigan water hammer pulse, Duroziez's double shock sound in the femorals, capillary pulse. These are absolutely characteristic; the diagnosis cannot be made without them. The original descriptions are:

Corrigan's Pulse (1832). "When a patient affected by the disease is stripped, the arterial trunks of the head, neck and superior extremities immediately catch the eye by their singular pulsation—the subclavian, carotid, temporal, brachial and in some even the palmar arteries are suddenly thrown from their bed, bounding up under the skin."

Duroziez's Sign (1861). "The double intermittent crural murmur in aortic insufficiency, most commonly is not present and it is necessary to produce it by means of compression. The finger pressing on the artery about 2 cm. above the stethoscope produces the first sound; 2 cm. below the stethoscope the second murmur is produced."

Capillary Pulse.—(Quinke: Berlin klin. Wehnschr., 1868.) "The capillary pulse one can see best on one's own fingernail, or better on that of another, in the area between the whitish blood-poor area and the red injected part of the capillary system of the nail bed, with each heartbeat a forward and backward movement of the margin between the red and white part. The fingernails of everyone do not show this white zone. Under these conditions a clear zone on the nails can be produced by even pressure.

"In aortic insufficiency the capillary pulse is especially clear. In a horizontal position of the hand we see a rapid appearance and disappearance of the margin between the red and white zone with . . . lightninglike and evanescent reddening. . . . The index finger is best, . . . in the nail bed the average diameter of the capillaries is 0.003-0.008 while elsewhere in the body it is only 0.002-0.006. . . . In another place—namely, the retina—is an uniform reddening and diastolic pallor of the papilla."

(The capillary pulse can also be seen in the lips on pressure with a microscope slide, and on the forehead by stroking the skin with the fingernail until a red line appears.)

Another sign which is caused by the same mechanism (of strong systolic thrust and rapid diastolic collapse) has been called the *De Musset sign*. It was described not by a physician, but by Paul de Musset, brother of the poet, Alfred, in his *Biography of Alfred de Musset* (Paris, 1877) as follows:

"At breakfast one morning I noticed that my brother's head was bobbing involuntarily at each pulse beat. He asked my mother and me why we were looking at him with such a startled air. We told him what we saw and he said, 'I did not think you could see it: but I will reassure you.'"

"He made some sort of pressure on his neck with his index finger and thumb and in a moment his head stopped marking his pulse. 'You see,' he then said to us, 'this dreadful illness can be cured by simple and inexpensive means.'"

5. Blood Pressure.—No point of diastolic pressure can be made out: the murmur (second or third phase) persists until the mercury column reaches zero.

6. Confirmatory Laboratory Signs.—X-ray examination shows left ventricular hypertrophy. The specific serum tests are positive for syphilis.

Austin Flint murmur is present in about 50 per cent of cases. It is a diastolic or presystolic murmur at the apex, closely imitating that of mitral stenosis. At autopsy no mitral disease is found. The murmur occurs during the meeting of the two columns of blood, one coming from the aorta, one from the auricle; at the moment of auricular contraction the extra thrust causes a presystolic murmur. I have never felt a thrill with the Austin Flint murmur.

Dr. Flint (Am. J. M. Sc. 44: 29, 1862) himself stated: "A mitral direct murmur, then, may exist without mitral contraction and without any mitral lesions, provided there be aortic lesions involving considerable aortic regurgitation. The murmur by no means accompanies aortic regurgitation lesions as a rule."

Balthazar Foster (Pathological Transactions Med. Times and Gazeette 18: 49, Dec., 1873, London) described the propagation of aortic regurgitant murmurs to the apex and ensiform. These were diastolic, differing from the mitral murmur in diminishing instead of increasing in intensity up to the first sound. This has been designated the Foster murmur and is occasionally referred to in the literature.

Flint described his murmur as blubbery and thought it due to the "floating up of the mitral leaflets with the filling of the left ventricle." The mitral direct current passes over the mitral curtains, and they are caught between it and the current coming down from the aorta, causing them to quiver in a "blubbery" way. Herrmann (The Austin Flint Phenomenon, Am. Heart J. 1: No. 6, Aug., 1926) has strengthened this hypothesis greatly by showing that when the Flint murmur is present, it is the posterior cusps of the aortic valve which are destroyed; this throws the stream directly against the mitral leaflets. Those interested should study the anatomic diagram in Herrmann's paper.

Aortic Stenosis—Calcification of the Aortic Valve.—Systolic murmur with thrill in the aortic region and ventricular hypertrophy is common. Aortic stenosis alone without accompanying regurgitation is rare. What is found at

2. Late or intermittent cyanosis—in which a communication between the venous and arterial circulation exists, such as a patent ductus arteriosus, or localized interventricular septal defect, but so small that under normal conditions with the higher pressure in the left ventricle no venous to arterial shunting occurs until the ventricular muscle becomes weakened.

3. The cyanotic, clubbed finger group (*morbus caeruleus*) in which mixture of venous and arterial blood takes place freely and the oxygen-unsaturation of the capillary blood is raised above its threshold value for the appearance of cyanosis.

The clinician can be expected to recognize with certainty and regularity only the third group. Nor does it make much difference whether he does or not.

Etiology.—Congenital heart anomalies are estimated to constitute about 2 per cent of all organic heart lesions, but such incidence from a clinical standpoint is far lower than that. In a large medical clinic in which we gather, record, and list cases of organic heart disease in order to demonstrate the signs of physical diagnosis to students, the incidence of recognized congenital defects in ten years has been less than 0.5 per cent.

The cause of congenital heart disease is failure of the heart and vessels to develop in normal evolution. Considering the intricacy of the process of the development of the heart and vessels, the wonder is not that the process sometimes goes wrong, but that it ever goes right. Most of the subjects die during intrauterine life. Among 139 autopsies on premature infants, Araya and White (*Am. Heart J.* 25: 449, April, 1943) found three cases of congenital heart malformation.

DESCRIPTION OF INDIVIDUAL LESIONS.—It is not within the scope of this book to discuss all the congenital lesions individually. The interested scholar will find a complete coverage in the monographs of Dr. Maude Abbott (*Blumer's Bedside Diagnosis* and *Nelson's Loose Leaf Medicine*). Dr. Abbott did such a complete job that these will probably never grow stale or become supplanted.

Coarctation of the Aorta is discussed under diseases of the aorta.

Patent Ductus Arteriosus.—The channel in the ductus may be so small that with more or less equal systolic pressure in the aorta and pulmonary artery no shunting of blood occurs, and there are no signs or symptoms. When the lumen of the ductus is large, no matter what the comparative ventricular pressure, there is a loud, harsh systolic murmur at the first or second left interspace. It may be also diastolic or continuous. A thrill of the same rhythm is likely to be present. Accentuation of the second pulmonic artery is usual. The pulmonary artery is unusually dilated and can be made out by percussion and by x-ray. The electrocardiogram is usually not abnormal. There is usually no cyanosis or clubbing.

The condition is not incompatible with fairly long life, although after the age of seventeen years the life expectancy is reduced 25 per cent. The great danger, as in all congenital heart lesions, is a superimposed bacterial endocarditis. Death was due to endocarditis in 40 per cent, to congestive failure

in 23 per cent, to rupture of a pulmonary aneurysm in 3.3 per cent, and to intercurrent disease in the rest of the cases in adults studied by Keys and Shapiro (*Am. Heart J.* 25: 158, Feb., 1943).

Patent Foramen Ovale.—An opening between the auricles may be anatomically open, but functionally closed. A murmur occurs in about half the cases. Its rhythm varies—systolic, diastolic, presystolic. It is heard best in the third or fourth left interspace. These patients are more subject to embolism than endocarditis. Mitral stenosis and patent foramen ovale constitute what is known as Lutembacher's syndrome. (See Uhley: *Am. Heart J.* 24: 315, Sept., 1942.)

Ventricular Septal Defects (Maladie de Roger).—The defect in most cases is small (barely admitting a knitting needle) at the base of the septum directly beneath the aortic valves. In only one-fifth of all cases does it occur as the sole anomaly. More than any others in the noncyanotic group these defects run their course symptomless. "Maladie de Roger" (Roger: *Bull. Acad. de méd.* 1879) consists of distinctive physical signs with absence of symptoms. A harsh, even murmur filling the entire systole, accompanied by a systolic thrill ($\frac{1}{2}$ of cases) with maximum intensity over the third and fourth interspaces near the left internal border or in midsternum. The reason there is no cyanosis is that the shunt is from left to right, the pressure being higher in the left ventricle, and arterial blood mixes with venous. This is an example of the fact that a small defect, producing no functional disturbance, can produce very marked physical signs.

Pulmonary Stenosis.—The symptoms here depend on circumstances. With a moderate stenosis, there will be a systolic murmur and thrill in the pulmonary region, but no cyanosis or cyanosis very late in life. With a high grade stenosis or atresia, the pressure in the right ventricle and auricle will be raised and either the interventricular septum or the foramen ovale will remain open, venous blood will mix with arterial, and cyanosis and usually clubbing will occur early.

The Tetralogy of Fallot.—(Fallot: *Marseille méd.* 25: 77, 138, 207, 270, 341, 403, 1888.) This consists of (1) stenosis of the pulmonary artery, (2) interventricular septal defect, (3) deviation of the aorta to the right, and (4) hypertrophy of the right ventricle.

It is commonest of the combined defects. There is always cyanosis and clubbing. Dusky skin of the retina, with engorgement and tortuosity of the vessels is common. The patients are usually stunted in growth and mentality, although there are notable exceptions to this rule.

Physical signs are precordial bulging and epigastric bulging, deviation of the apex to the left; enlargement of the right side to the right of the sternum is usually sufficiently marked that it can be made out on percussion. A systolic murmur and a systolic thrill are present in the second and third interspaces. They are marked and harsh, often transmitted into the vessels of the neck.

The x-ray is useful to confirm the right-sided hypertrophy. The electrocardiogram shows right ventricular preponderance (greater than ever seen in

mitral stenosis), and usually ventricular extrasystoles. The increase in size of the right auricle is indicated by a high P wave, especially prominent in the second lead. The capillaries in the nail bed, as seen with the capillary microscope, are more markedly dilated than in any other condition.

The prognosis is unfavorable, few subjects surviving the twenty-fifth year of life. White and Sprague (J. A. M. A. 92: 787, March 9, 1929), however, record a remarkable case of a distinguished American composer of music, who lived to the age of sixty. He was cyanotic from birth, but of average physical size, and besides his unusually brilliant career in music, carried on the ordinary normal activities of life, was married and had two daughters.

V. BLOOD PRESSURE

The American Heart Association, recognizing that there was a serious lack of agreement among physicians about the correct technique for taking and interpreting the blood pressure, appointed a committee which, working with a committee of the Cardiac Society of Great Britain and Ireland, in 1939 formulated a standard method for taking and recording blood pressure readings. (*Am. Heart J.* 18: 95, July, 1939.) This method is as follows:

(1) **BLOOD PRESSURE EQUIPMENT.**—The blood pressure equipment to be used, whether mercurial or aneroid, should be in good condition and calibrated at yearly intervals for accuracy, and more often if defects are suspected (mercurial preferred by British committee).

(2) **THE PATIENT.**—The patient should be comfortably seated (or lying—British committee) with the arms slightly flexed and the whole forearm supported at the heart level on a smooth surface. If readings are taken in any other position, a notation should be made. The patient should be allowed time to recover from any recent exercise or excitement. There should be no constriction of the arm due to clothes or other objects.

(3) **POSITION AND METHOD OF APPLICATION OF THE CUFF.**—A standard sized cuff containing a rubber bag from 12 to 13 cm. in width should be used. A completely deflated cuff should be applied snugly and evenly around the arm with the lower edge about 1 inch above the antecubital space and with the rubber bag applied over the inner aspect of the arm. The cuff should be of such a type and applied in such a manner that inflation causes neither bulging nor displacement.

(4) **SIGNIFICANCE OF PALPATORY AND AUSCULTATORY LEVELS.**—In all cases palpation should be used as a check on auscultatory readings. The pressure in the cuff should be quickly increased in steps of 10 mm. of mercury until the radial pulse ceases and then allowed to fall rapidly. If the radial pulse is felt at a higher level than that at which the auscultatory sound is heard, the palpatory reading should be accepted as the systolic pressure; otherwise the auscultatory reading should be accepted.

(5) **POSITION AND METHOD OF APPLICATION OF STETHOSCOPE.**—The stethoscope should be placed over the previously palpated brachial artery in the antecubital space, not in contact with the cuff. No opening should exist between

of whorls, eddies and swirling at the point below the constriction, just as the murmurs of relative aortic stenosis are produced. The dilatation below the point of constriction permits a sudden release of fluid blood under greater tension than that which exists below this point. That such is the true mechanism has been proved by placing a second constrictor below the point of auscultation and thus raising the pressure in the vessel under the stethoscope and creating stagnation. When this is done, the murmuring sounds do not occur. Similarly, the sounds are much more marked upon deflation than upon inflation of the constricting cuff. These sounds of the second phase are purely transitory, for if such partial compression as exists at this phase is maintained for twenty to forty seconds, the hissing murmurs disappear, as the pressures above and below the cuff become equalized. Such an absence of sound at this phase has been spoken of as the 'auscultatory gap' in sphygmomanometry.* It is found only in patients having a hypertension or in a few with aortic stenosis. There is no definite prognostic significance, but the occurrence of this unusual silence must be kept in mind as a real source of error.

Phases		Sounds
1.	S	Clicks
2.		Soft murmurs
3.		Thuds
4.	D	Softened, muffled sounds
5.		Silence

FIG. 23.—Diagrammatic representation of sounds heard upon auscultation during sphygmomanometry. S, point at which systolic pressure is read; D, point at which diastolic pressure is read.

"The disappearance of the murmur is associated with an increase in the volume of flow and an increase in the peripheral resistance, and also a diminution of the degree of arterial compression. The last factor reduces the water hammer action but the partially collapsed artery opens and closes with each systolic pulsation. The origin of this sound is in the arterial wall which is forcibly stretched out between each period of collapse. Thus this third phase of sound is often altered in quality by the status of arterial tonus. A rigid or tense elastic arterial wall results in a sharper, louder sound than a flaccid wall, similar to the difference in the note obtained from a tense or slightly relaxed drum. The viscosity and freedom of flow of the blood are also factors. In cases of polycythemia vera a dull, sticky note is heard in which it is very difficult to differentiate the phases.

*This "auscultatory gap" first described by Cook and Tausig (J. A. M. A. 68: 1033, 1917) is warned against as a possible source of error in estimating diastolic pressure. In about 5 per cent of patients with hypertension there is a complete disappearance or enfeeblement of the sound during the second phase, so it may be taken by the examiner as the cessation of all sounds or diastolic pressure. If deflation is continued the sounds recur.

"The fourth phase, or the dulling of the thuds with marked muffling, appears when maximal filling and collapse of the artery cease. It is this point that registers and indicates the diastolic pressure. It was formerly conceived that the complete disappearance of all sound (the fifth phase) represented the diastolic pressure, but many investigations have shown this older view to be erroneous. Erlanger pointed out that the dulling of sound, or 'change in note' as it is more commonly described, occurs when the artery no longer collapses during diastole. Therefore, the occurrence of the change in note at the onset of the fourth phase corresponds to the diastolic pressure.

"The onset of the fifth phase of silence may occur almost immediately or at a point considerably lower in the scale of pressure. In a study of 118 cases the average difference was 14 mm. It has been clearly demonstrated that taking the diastolic reading at the onset of the fifth phase is wrong, and that the error may range from 5 to 55 mm. In certain pathologic states, such as free aortic regurgitation, the fourth phase may be greatly prolonged, as it is in Duroziez's sign, but this does not indicate an actual diastolic pressure as low as 8 or 10 mm. A long third phase is said to indicate a powerful systole and this phase is also lengthened in arteriolar sclerosis. In the presence of cardiac embarrassment the tones may vary greatly with each pulsation, some being strong and loud, and others weak and muffled as the force of the ventricular contractions vary."

Normal Blood Pressure.—

In new-born babies Reis and Chaloupka (Surg., Gynec., and Obst. 37: 206, 1923) found this average daily systolic reading:

DAY	1	2	3	4	5	6	7	8	10
	43	48	55	59	63	66	70	73	78

After the tenth day it became fairly stabilized around 80.

In children Judson and Nicholson (Am. J. Dis. Child. 8: 251, 1914) found the following averages:

AGE	SYSTOLIC	DIASTOLIC
3 years	91	65
4 years	91	64
5 years	91	61
10 years	99	67
12 years	102	65

In adults from many thousand readings in all age groups the following may be taken as average:

AGE	SYSTOLIC	DIASTOLIC
20-40 years	112-125	60-80
40-60 years	125-135	80-85
60-80 years	135-165	50-75

No explanation of why blood pressure rises so rapidly during the first year of life, why it should be twice as high at the third year as at birth, is satisfactory. The idea that the blood plasma is more viscid and requires more pressure to force it through the kidney glomeruli may hold for the first year, but after eighteen months at most the blood plasma protein is the same as the adult's. Size of the body has nothing to do with it: the blood pressure of human beings, dogs, mice, rabbits, and cats is the same.

In any single individual the blood pressure varies slightly during the twenty-four hours. It is lowered during sleep. Campbell and Blankenhorn (*Am. Heart J.* 1: 151, 1925) found that in twenty-five normal young men the blood pressure dropped from 110 to 101 during sleep. The low point was reached about four hours after the beginning of sleep. Of thirty-six patients with elevated blood pressure, only one showed a drop during sleep. It is low in the morning and rises slightly with the activities of the day. It rises sharply after exercise.

It varies somewhat in different races. Cadbury (*Arch. Int. Med.* 30: 362, 1922) found that among healthy Cantonese (South China) students the systolic pressure averages from 20 to 30 mm. Hg less and the diastolic from 10 to 20 mm. Hg less than the standards for European and American men of corresponding age and bodily constitutions. Tung (*Chinese J. Physiol.* 41: 117, 1930) found that natives of northern China showed a mean systolic pressure of 102 mm., diastolic 64, for ages fifteen to nineteen years and 113/73 for fifty to fifty-four years. Tung (*Chinese J. Physiol.* 1: 93, 1928) also showed that thirty Chinese students who went to America had a drop in systolic pressure of 11 mm. and in diastolic of 8 mm. after they returned to China. Americans living in China also experience a drop in blood pressure during their Chinese residence. (Foster: *Arch. Int. Med.* 40: 38, 1927.) Krakower (*Am. Heart J.* 9: No. 3, Feb., 1934) found among 239 Chinese living in Montreal that the average blood pressure is consistently 10 mm. Hg higher than that reported for Chinese natives, and among them hypertension occurs with surprising frequency (11.2 per cent) in contrast to its rarity in China. Hashimoto and colleague (*Ann. Int. Med.* 7: No. 5, Nov., 1933) found that hypertension among urban Japanese is much higher than among Chinese natives.

These statistics have been used largely to bolster up the argument in favor of high pressure modern life being the cause of hypertension. But climate has a regular effect on blood pressure. Roddis and Cooper (*J. A. M. A.* 87: 2053, 1926) state that the native of the tropics has a lower blood pressure than the temperate zone standard. Northern-born white men who come to the tropics develop blood pressures 10 to 15 mm. below normal for the temperate zone. The change is a gradual one.

Body weight does not have any marked influence per se, although much has been made of the association of overweight and hypertension. Huber (*J. A. M. A.* 88: 1927) in a careful study, found that 49 per cent of those 10 per cent underweight have a subnormal blood pressure; 18 per cent of those 10 per cent underweight have a hypernormal blood pressure; 22 per cent of a group with a systolic blood pressure over 140 were underweight. Fourteen per cent of the group with blood pressure over 140 are underweight; 53 per cent with a blood pressure under 110 are underweight; 6 per cent of those with a blood pressure under 110 are overweight.

Pregnancy uncomplicated has no influence. Irving (*J. A. M. A.* 66: 1916) found that 80 per cent of a consecutive series of pregnant women had an average systolic pressure of 110 to 130.

Alvarez (*Arch. Int. Med.* 26: 381, 1920) advanced the belief that blood pressure readings, as gathered by life insurance companies, while valuable, were obtained from too selected a group. In examining students in a state university he suggested that systolic pressures above 130 in women and 140 in men are abnormal. He also pointed out the surprising amount of slight hypertension among young males; 45 per cent of the young male students he examined had systolic pressures over 130 and 22 per cent were above 140.

It is a mistake to speak of "normal" blood pressure. Average blood pressure is a better term. A "normal" blood pressure would be the result of a normal systolic contraction of the ventricles, sustained by a normal elasticity of the arterial walls, with a normal blood plasma concentration and a normal renal filter, under normal conditions of balance of the autonomic nervous system, and a normal mental state, at a normal age, with a normal body build—and these are all abstractions.

The average blood pressures in the group over fifty are higher than most of the statistical tables indicate. All the tabulators tried to get healthy persons; the life insurance companies automatically got persons who thought they were healthy.

High Blood Pressure.—The causes of high blood pressure are essential hypertension, malignant hypertension, nephritis, toxemias of pregnancy, intracranial pressure, hyperthyroidism, adrenal tumors, neurocirculatory asthenia, and polycythemia.

Low Blood Pressure.—Any debilitated state of health causes low blood pressure. Nearly all infectious diseases induce lowered blood pressure. Collapse from infection or surgical shock produces profound lowering of the pressure. Prolonged low blood pressure is found in tuberculosis, anemia, and Addison's disease.

Extremes of Blood Pressure Compatible With Life.—Hirst reported a systolic pressure of 420 mm. Hg in a case of puerperal eclampsia. Strauss had a patient who lived five years under observation with a systolic pressure between 260 and 270 mm. McCurdy (*J. A. M. A.* 65: 2052, 1915) reported many patients with blood pressures of 200 systolic and 120 diastolic who lived for years at hard manual labor. Rollerton reported a case of a man with cancer of the tongue who lived for several weeks with a blood pressure of 70 systolic and 35 diastolic.

Clinical Value of Blood Pressure Determinations.—Probably no equally simple procedure except taking the temperature and counting the pulse gives such a reliable idea of the general state of the health. In persons over forty-five it gives an idea of the general condition of the vital organs—the heart, arteries and kidney—which can be obtained in no other way. The life insurance companies, whose business success depends upon prognosis, have long since found that they can calculate the exact degree of impairment in a group of risks better by blood pressure than by anything else. The Northwestern Life Insurance Company in a series of applicants rejected with an average

systolic pressure of 161.4 mm. Hg had 83 deaths within six years, where the expected deaths would be 43, a per cent of actual to expected deaths of 189.9 per cent.

Arteriosclerosis. Hypertension

The arteries all over the body are subject to a progressive tissue change beginning probably at an early period in life and accelerated at about the age of forty.

The change may be called arteriosclerosis, but is subject to endless variation in different persons. The process may affect different coats of the arteries. It may advance to different stages; it may become stationary. It may affect a few arteries, or it may be very widespread and universal. It may affect predominantly large arteries, medium-sized arteries, or arterioles. It may or may not be accompanied by heightening of the blood pressure or hypertension.

The following syndromes may be found.

CEREBRAL. Cerebral arteriosclerosis with deterioration of memory and mental powers. Thrombosis or hemorrhage of vessels, with hemiplegia, aphasia, etc.

OCULAR. Retinal hemorrhage—albuminuric retinitis, diabetic retinitis.

FACIAL. *Tie douloureux*.

THYROID. Myxedema.

AORTIC. Atheroma. Dissecting aneurysm.

CARDIAC. Angina. Coronary thrombosis.

PULMONARY. Emphysema. Chronic bronchitis. Bronchiectasis. Ayerza's disease.

PANCREATIC. Diabetes.

RENAL. Chronic glomerulonephritis.

UTERINE. Senile uterus.

PROSTATE. Hypertrophy.

OVARIES AND TESTES. Menopause.

EXTREMITIES. Intermittent claudication. Arteriosclerotic gangrene. Diabetic gangrene.

Possibly thrombo-angiitis obliterans and periarteritis nodosa are forms of the disease.

Hypertension.—Definition.—Robinson and Brucer (*The Range of Normal Blood Pressure*, Arch. Int. Med. 64: No. 3, Sept., 1939), after a statistical study of over 10,000 persons and a five to ten year study of a group of 500, conclude that the normal range of systolic blood pressure is 100 to 120 mm. of mercury, of diastolic 60 to 80 mm. of mercury, for men and women, that a normal person attains his mature blood pressure at about adolescence and keeps that range throughout life, except for a slight rise at about the twentieth year.

The cause of the rise of blood pressure with advancing age is an unexplained fact. The increasing size of the animal has nothing to do with it. Adult rabbits, mice, dogs, goats, horses, and men all have an arterial pressure of about 120/80. The explanation that such a pressure is necessary to filter off fluid from the glomeruli of the kidneys against the osmotic pressure of the

plasma colloids, hardly stands up when we recall that a child of eighteen months, with the same plasma protein as an adult man has an arterial pressure of 80/55.

Hypotension (110/70) is the ideal blood pressure level and is found in between one-third and one-fourth of the population. A person with a history of pressures which occasionally dip to 90/60 has an assurance of not becoming hypertensive. Transient elevations of blood pressure, and moderately high pressures at ages 20 to 30 are incipiently hypertensive. High blood pressure is a long-term disease having its genesis at an early age. It is not a disease that suddenly emerges in middle age.

Weight and body build are generally considered to have an influence in the development of hypertension. Thus Alvarez says that "men with normal weight average 10 mm. more than do the lean, and the stout average 13 mm. higher than the normal." But the point has been overemphasized in most of the literature. Thus Dunham (International Clin. Vol. III, 35th Series, 1925) found the mean blood pressures by weight groups are for the 40 or more pounds underweight 123 S and 77 D; for 40 or more pounds overweight 137 S and 85 D.

Hereditry.—Hereditary disposition to arteriosclerosis and to both essential and malignant hypertension is very striking. Weitz (Hypertension. Leipzig, 1926) made the most exhaustive study of it and concluded that the tendency was a dominant Mendelian character. Among 82 patients with hypertension he found nearly 92 per cent showed some evidence of family tendency. In 267 controls 30.3 per cent had lost a parent from the consequences of hypertension. In 50 patients whom I examined over the age of fifty with both parents living, only seven of the 150 individuals involved had a systolic blood pressure over 150, and none over 180.

Every physician knows of families where apoplexy and Bright's disease affect member after member. I once attended three brothers in succession who developed albuminuria, with blood pressure around 200/100 at about the age of forty: all died of uremia or heart failure before fifty: the father had died suddenly of a stroke at fifty-five. Juvenile cases of hypertension notably have a bad family history. One of my patients, a male, died of uremia at sixteen; he had for years had heavy albuminuria and a systolic blood pressure often too high for my instrument to record. His mother had eclampsia during her first pregnancy and was warned on account of persistent albuminuria not to become pregnant again, which she disregarded: when my patient was four years old his mother died at the age of thirty-six of uremia, which had long been threatening.

Hines (Ann. Int. Med. 11: 593, Oct., 1937) used a test in which after a period of rest, the hand was placed in ice water and the blood pressure response noted. In seven sets of identical twins the reactions were similar. In 12 families with no evidence of hypertension and 18 families with one or more parents with hypertensive tendencies, it was found that if both parents had hypertension, 95 per cent of the children had hypertension or was a hyper-

reactor to the test; if one parent was hypertensive, 43.4 per cent of the children had hypertension or were hyperreactors, and when both parents were normal all the children were normal reactors.

Incidence of Hypertension.—When I began to investigate this phase of the subject, I found that curiously enough there are almost no data. I found plenty of investigations which showed the average blood pressure in different age groups (see p. 350), but only a few reports about the number of persons who had a systolic pressure over 150 and a diastolic pressure over 90 in the age groups of 20-30, 30-40, 40-50, 50-60, etc.

The question is of great importance. If hypertension is not so much an abnormality but a finding so constant as to constitute so considerable a percentage of those over the age of 40, and especially over the age of 50, as to be almost normal for certain types of individuals, it would require a different orientation in our viewpoint.

Some few reports were found:

Janeway reported that 11.1 per cent of 7,872 private patients had systolic blood pressures above 165 mm.

Wundt, quoted by Janeway, found in an older group the following percentages:

AGES	SYSTOLIC OVER 150 (%)	SYSTOLIC OVER 200 (%)
65-69	49	3
70-74	44	6
75-79	39	7
80-82	38	12
85-89	61	14

Diehl and Sutherland (Arch. Int. Med. 36: No. 2, Aug., 1925) found in a group of university students that 1.2 per cent showed persistent hypertension.

Dr. Chester T. Brown, Medical Director of the Prudential Life Insurance Co., in response to my request, had no statistics available, but courteously offered to go over the figures of the company and found that in all applicants during a six months' period—first half of 1941—the following results:

GROUP I. Applicants with systolic pressure of 150 or over, diastolic pressure as indicated:

AGES	UNDER 90 (%)	90 OR OVER (%)	TOTALS (%)
Under 39	0.51	0.91	1.42
40-49	2.15	6.81	8.96
Over 50	4.45	12.04	16.49

GROUP II. Applicants with systolic pressure 180 or over, diastolic pressure as indicated:

AGES	UNDER 90 (%)	90 OR OVER (%)	TOTALS (%)
Under 39	0.02	0.10	0.12
40-49	0.24	2.17	2.41
Over 50	0.63	4.79	5.42

GROUP III. Applicants with systolic pressure of 200 or over, diastolic pressure as indicated:

AGES	UNDER 90 (%)	OVER 90 (%)	TOTALS (%)
Under 39	0.00	0.03	0.03
40-49	0.05	0.66	0.71
Over 50	0.13	1.60	1.73

The Metropolitan Life Insurance Co. reports (Statistical Bulletin 4. No. 10, Oct., 1923) on over 16,000 males, the percentages of those with blood pressure 20 mm. or more above average for age:

AGE	NORMAL WEIGHT (%)	20 PER CENT OR MORE OVERWEIGHT (%)
Under 25	5.6	5.1
25-34	4.5	11.2
35-44	4.0	10.7
45-54	8.2	22.4
55 or over	23.0	32.0

The Life Extension Institute (Proceedings of the Life Extension Examiners 1: No. 3, May-June, 1939) examined 10,000 apparently healthy persons geographically from every part of the United States and found the age distribution as follows:

AGE	SYSTOLIC PRESSURES		DIASTOLIC PRESSURE
	150 MM. OR OVER (%)		100 MM. OR OVER (%)
10-19	Men	0.5	0.5
	Women	0.5	0.0
20-29	Men	1.0	1.5
	Women	0.4	1.0
30-39	Men	2.0	2.0
	Women	2.9	2.1
40-49	Men	6.0	4.0
	Women	10.0	5.0
50-59	Men	30.0	9.0
	Women	45.0	14.0
60 & over	Men	38.0	14.0
	Women	55.0	16.0

I was not satisfied with these statistics partly because most of them represented life insurance experience which, ipso facto, deals with persons who are, so far as their own knowledge and belief go, in good health. I requested a number of my colleagues in clinic and private practice to send me blood pressure readings on consecutive patients over the age of twenty, and received data on 2,127 patients.

Of the 2,127 patients, 629 or 29.57 per cent had systolic blood pressure of 150 or over. More than two-thirds of these were over forty years of age.

Of the 2,127 patients 881 were under 40 and 197 of these, or 22.3 per cent had systolic blood pressures over 150.

One thousand two hundred and forty-six patients were over forty, and 432, or 34.6 per cent, had systolic pressure over 150.

From these various statistics, conflicting as they are, certain definite conclusions can be drawn. First, blood pressure is generally low up to the age of thirty and then begins to rise sharply so that at the age of forty about 10 per cent of the population have a systolic pressure over 150 and about 6 per cent have a diastolic pressure over 90, and at the age of fifty about 25 per cent of the general population have a systolic pressure over 150 and 12 per cent have a diastolic pressure over 90. This is an average of the supposedly "well" and the allegedly "sick" groups in the population.

Juvenile Arteriosclerosis.—Zeek (Arch. Path., Sept., 1930) collected 98 cases of arteriosclerosis in children all under sixteen years of age and most of them under ten years of age: among them was one stillborn, one 2 weeks old, one 6 months old, and one 2 years old.

Hypertension in Childhood.—Liebenau (Monatschr. f. Kinderh. 63: 171, 1935) reports a child, nine and one-half years of age, with a pressure of 145/110. There was no albuminuria; N. P. N. 38 mg. The father, aged thirty-five years, had a pressure of 155/78. Sobel (Am. J. Dis. Child. 61: 28, Feb., 1941) reports seven cases of essential hypertension in children, one four years old with a pressure of 170/120, albuminuria, etc.

"According to the statistics of the Metropolitan Life Insurance Company every other individual in the United States past the age of fifty dies of cardiovascular-renal disease." (Smith, Weiss, Lillie, Konzelmann and Gault: *Cardiovascular-renal Disease*, D. Appleton-Century Co., 1940.) The death rate per 100,000 population is negligible until the age of 35.

It rises very gradually until the age of 45 when it begins to rise sharply, reaching 750 per 100,000 population at about the age of 52, then continuing its sharp rise until at 60 it is 1,000, and at 70, 2,500. While the actual number of deaths was much greater in 1940 due to the increase in those of older ages in the population, the proportionate death rate for age groups has not changed essentially since 1911. (And probably at any time before since these dates represent simply the time when statistics became reliable.)

Forms of Hypertension.—Blood pressure either high or low is, of course, simply a physiologic response to something. As to what that something is there is no reason to go back on the old idea that blood pressure is the resultant of two factors: (1) the strength of the systolic cardiac impulse, and, (2) the peripheral resistance. There are many transitory forms of hypertension—that of hyperthyroidism and of Graves' disease, of intracranial pressure, the paroxysmal hypertension of adrenal paraganglioma, and of pregnancy. In connection with the last, it should be remembered that eclampsia rarely if ever occurs before the sixth lunar month, and that if recovery occurs there is rarely any evidence in later life of vascular or renal damage. Pre-existing vascular or renal disease or larval essential hypertension when aggravated by pregnancy into what may be generically termed the toxemia or kidney of pregnancy usually begins to manifest signs before the twenty-fourth week and after the termination of pregnancy may often go on to renal and vascular

changes in the form of benign or malignant hypertension. (See valuable article by Judson A. Smith: *The Medical Aspects of Obstetrics*, New England J. Med. 226: No. 1, Jan., 1942.)

Forms of Essential Hypertension.—Every clinician recognizes that hypertension manifests clinical forms of varying degrees of severity. The syndrome of malignant hypertension is characterized by its occurrence in younger patients—33 to 55 years, average 40: the high pressures (systolic 250, diastolic 150 is not unusual): characteristic retinal picture: simultaneous functional failure of brain, kidney, and heart: bad prognosis and early death, a liability to apoplexy with massive hemorrhage into the ventricles; and "the characteristic histologic observation of diffuse general hypertrophy of the arterioles." (Keith, Wagener, and Kernohan: *Arch. Int. Med.* 41: 141, Feb., 1928.)

CLASSIFICATION OF DIFFUSE ARTERIAL DISEASE WITH HYPERTENSION*

SEVERITY INCREAS- ING BY GRADE	SYMPTOMS AND SIGNS	MEAN AGE OF GROUP	SURVIVAL AFTER FIRST EXAMINATION
Grade I	Can be of long duration without causing any symptoms or impairing general health. Cardiac and renal functions good. May be slight albuminuria. Eye grounds normal. Hypertension seldom of high degree.	55	50 per cent alive ten years later Average duration of life after first examination 100 months.
Grade II	Higher and more sustained hypertension than in Group I. May be more nervous, but their cardiac and renal functions are satisfactory. Some percentage of retinal changes.	41	30 per cent alive ten years later. Average duration of life 63 months.
Grade III	Hypertension high and sustained. Dyspnea on exertion, headaches, vertigo, visual disturbances, and nocturia. Albuminuria. Retinal angiospastic changes. Electrocardiographic changes.	40	88 per cent dead after ten years Average duration of life 15 months.
Grade IV	High pressures recorded. Symptoms such as nervousness, dyspnea, loss of weight, fatigue may incapacitate. Marked retinal changes. Albuminuria, nocturia, cylindruria. Cardiac, renal and cerebral failure likely to be present.	40	97 per cent dead after ten years. Average duration of life 5½ months.

*Adapted from Keith, Wagener, and Barker: *Am. J. M. Sc.* 197: No. 3, March, 1939.

Periarteritis nodosa might be called Buerger's disease of the visceral arteries. It is an inflammatory panarteritis affecting the medium-sized and small arteries. The cause is unknown, association with rheumatic endocarditis, scarlet fever, and tonsillitis being reported. Both sexes are equally affected. Fifty per cent of cases occur in the third and fourth decades. Keith and Baggenstoss (*J. Ped.* 18: No. 4, April, 1941) gathered reports of forty-four cases among children.

The incidence of the disease is difficult to determine. Formerly regarded as rare, of late years cases are accumulating in mounting numbers in the literature. It should probably be regarded as an unusual but sufficiently frequent clinical condition as to require constant vigilance on the part of the clinician.

Pathologically all coats of the arteries are affected. There is infiltration by leucocytes of all varieties into the adventitia, vasa vasorum, and perivascular tissues. Necrosis of the media leads to the development of multiple small aneurysms which may be followed by rupture or fibrosis. There is also proliferation and degeneration of the intima with thrombosis and arterial obstruction. Nearly any organ may be the brunt showing preponderant changes, the liver, spleen, kidneys being perhaps the commonest with the gastrointestinal tract, skin, and heart coming next.

The multiform possibilities of presenting symptoms and signs make the diagnosis very confusing. But despite pessimistic statements to the contrary, the diagnosis can be made, as witness two case records of the Massachusetts General Hospital (New England J. Med. 220: No. 14, April 6, 1939, and 222: No. 19, May 9, 1940). I am not sure but that aspiring diagnosticians can learn more by reading these reports than by studying all the other literature.

The symptoms, given in the order of frequency, are first the general symptoms: fever (6), loss of weight (5), edema (5), weakness (5), leucocytosis (5), hypertension (5), dyspnea (4), emaciation (4). (See Harris, Lynch and O'Hare: Arch. Int. Med 63: No. 6, June, 1939.) Eosinophilia, if persistent, is significant; it may go as high as 68 per cent. Lebowich and Hunt (Am. J. Clin. Path. 10: No. 9, Sept., 1940) state that any persistent eosinophilia in an obscure case should suggest periarteritis nodosa.

Symptoms or signs which point to a special involvement are in order of frequency: cough (4), abdominal pain (4), albuminuria (4), hematuria (4), icterus (3), sensory involvement (3), arthritis (3), vomiting (2), cyanosis (2), visual disturbance (2), nodules (2), neuritis (2), nausea (1), convulsions (1), pain in chest (1), purpura (1).

The disease has a rapid onset in about half the cases. The other half show recurrent episodes involving different groups of organs, or sometimes recurring in the same organs, or slow gradual vague febrile illness.

Several groups of *pointing* signs and symptoms are common, showing the involvement of different organs. Renal site is perhaps the commonest, then lung, abdominal, hepatic, and cerebral.

The renal site may mimic anything—peptic ulcer with hemorrhage or with perforation, typhoid fever, cholecystitis, pregnancy, appendicitis, Henoch's purpura, regional ileitis, pancreatitis, enlarged spleen. Allen's patient (Arch. Surg. 40: No. 2, Feb., 1940) was operated upon under the diagnosis of perforated ulcer; at operation an inflamed gall bladder and appendix were removed; histologic examination of which organs showed the true nature of the condition. (See also Boyd: Bull. New York M. Coll., Flower and Fifth Ave. Hosps. 4: No. 1, April, 1941.)

When the lesions predominate in the lungs, the differential diagnosis will have to be made from bronchopneumonia, miliary tuberculosis, infarct, lung abscess.

The cutaneous manifestations are also varied. It was once believed that the disease was caused by syphilis. The skin lesions may resemble syphilis,

scarlet fever, lupus, erythema nodosum, purpura hemorrhagica, bacterial endocarditis. (Boyd: Periarthritis Nodosa, Bull. New York M. Coll., Flower and Fifth Ave. Hosps. 3 No. 3, Oct., 1940.) The cutaneous manifestations are important because a biopsy can be obtained which may clinch an obscure diagnosis. Lundberg found twenty-one cases with exclusive cutaneous involvement. The dermal nodules of periarthritis nodosa are mentioned in only fifty-six cases, but re-examination of the skin after the disease is discovered at autopsy has repeatedly demonstrated their existence.

Lesions of the large peripheral arteries are not uncommon and produce gangrene of the extremities. In its purest form periarthritis nodosa is characterized by livido racemosa.

Central nervous involvement often results in hemorrhage, and has been mistaken for meningitis, Wilson's disease, Polyneuritis, radiculitis, sciatica, von Recklinghausen's disease.

The general febrile onset will have to be distinguished from trichinosis (the eosinophilia is confusing here) indulant fever, miliary tuberculosis, typhoid fever, cerebrospinal meningitis, rheumatic fever, and typhus fever.

The cutaneous or subcutaneous nodules when present, which is in about 10 per cent of cases (Curtis and Coffey: Ann. Int. Med. 7: No. 11, May, 1934) may be like papules or like small nontender lymph nodes under the skin. They vary in size from the size of a millet seed to that of a pea. If hemorrhage occurs, the dimension of a hen's egg may be attained. The dimensions vary in the same patient. Crops of nodules may recur daily or at intervals. The forearms, chest, legs, thighs, abdomen, face, ankles, back, fingers, soles of feet, scalp, scrotum, and tongue are the sites in order of frequency (see Ketron: Cutaneous Manifestations of Periarthritis Nodosa, Arch. Dermat. and Syph. 40: No. 6, Dec., 1939).

The peripheral nervous and muscular form exhibits "arthralgias," polyneuritis, or myositis with pain, nerve trunk tenderness, diminution or loss of tendon reflexes, intermittent claudication (Boyd: Periarthritis Nodosa—The Neuromyositis Manifestations, Bull. New York M. Coll., Flower and Fifth Ave. Hosps. 3: No. 4, Dec., 1940).

Ayerza's disease is sclerosis of the pulmonary artery. In the advanced form it produces cyanosis and polycythemia—the *cardios negro* of the Spanish, *Cardiagne noir* of the French. This stage is often preceded by chronic bronchitis. Cough, hemoptysis, dyspnea, vertigo, and precordial pain are the most prominent symptoms. With the onset of cyanosis cardiac failure is manifest. Syphilis has been implicated as a cause. A systolic murmur in the pulmonary area, or indeed anywhere over the precordium, may be present.

Disseminated lupus erythematosus is a condition which has an inescapable clinical resemblance to periarthritis nodosa. The fundamental pathologic changes are in the finer vessels, and like periarthritis nodosa, it has a bewildering variety of visceral changes. Its onset is with polyarthritis, fever, leucopenia, and an erythematous eruption on the skin of the face and chest. See p. 358 and p. 359.

VI. EXAMINATION FOR CARDIAC FAILURE

In the criteria for classification of heart disease approved by the American Heart Association (1934) under physiologic defects appear (1) Adams-Stokes syndrome, (2) anginal syndrome, (7) bundle branch block, (8) cardiac insufficiency—congestive heart failure, (12) pulsus alternans. There are other headings, (3), (4), (5), (6), etc., comprising arrhythmias which may or may not be associated with failure, but the above represent a classification of what may be called heart failure. The classification is not very satisfactory, but no classification would suit everyone, and this will do for the purpose of discussion.

It is evident that heart failure falls into two great categories: failure with chronic passive congestion and failure without. The second class comprises various forms of block, anginal syndrome with or without infarction of the myocardium, and pulsus alternans. These present few signs to the unaided senses of the diagnostician; they are made known by the history or electrocardiographic tracings. The two physical signs of gallop rhythm and pulsus alternans are the exceptions. The syndromes are described elsewhere in this volume, and we shall not discuss them further now.

Congestive heart failure, especially in its minor manifestations, should, however, be the object of an especial search during the routine physical examination. The cardinal signs of congestive failure are:

1. Dyspnea, shortness of breath of some form or degree.

2. Chronic passive congestion of the lungs manifested by cough, blood tinged frothy sputum, or in its less extreme form by râles heard at the bases of the lungs behind. "Moist râles in the lower posterior lung borders may be the very earliest manifestation of heart muscle fatigue." (Crummer: *Heart Disease*, 1925.)

Such is the chronic condition. Acute pulmonary edema which we may assume results from acute left ventricular failure (*vide infra*) is one of the most terrifying experiences for the patient in the whole panorama of clinical medicine. The typical situation is of a middle-aged or elderly person who, suddenly upon some slightly exaggerated exertion, feels very breathless and then it seems as if all the fluid in the body had poured out into the alveolar spaces of the lungs; it overflows in bubbles of froth, pink usually, or coughing of enormous quantities of blood-tinged sputum. Pallor is marked. The attack may be fatal or may end as quickly as it came. Nine-tenths of the patients have hypertension or aortic disease, or coronary thrombosis has left an infarction in the left ventricle; occasionally it occurs late in mitral stenosis.

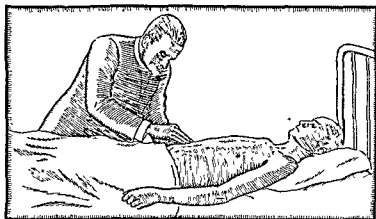
3. Hydrothorax, made evident of dullness on percussion, absence of vocal fremitus and absence of heart sounds.

4. Enlargement of the liver—the commonest cause of enlarged liver is chronic passive congestion (two-thirds of all cases). Abdominal pain may be the earliest indication.

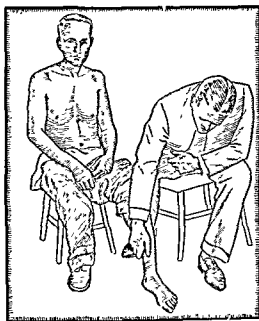
5. Ascites.

6. Edema of the ankles. "The engorgement of the liver, the often very perceptible augmentation of its size, an engorgement evidently produced by

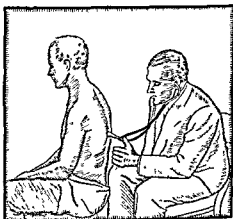
the accumulation or stagnation of the blood which cannot return to the heart without embarrassment, the swelling of the extremities in consequence of the infiltration of which they become the seat are so many signs presented to the observation of the practitioner." (Corvisart: *Diseases of the Heart*, 1812.)



A.



B.



C.

Fig. 34.—Examination for congestive heart failure. A. Palpation of liver. B. Edema of Ank'les. C. Auscultation of bases of the lungs

7. Albumin or blood in the urine.

8. Cyanosis properly does not belong to congestive failure. It is a late or transient accompaniment.

9. Jaundice is also not properly a part of congestive failure, though it occurs occasionally in a manner to be puzzling. Keefer and Resnik (*J. Clin.*

Investigation 2: 375, 1926) found it associated with pulmonary infarction. Congestion of the liver with anoxemia and impairment of its function may produce jaundice. Increased destruction of red blood cells is less important. Meakins (J. Clin. Investigation 4: 135, 1927) found in relative tricuspid insufficiency a positive direct van den Bergh reaction in the blood serum, and concluded that in such cases obstruction to the hepatic circulation due to increased venous pressure is the cause of the jaundice. He pointed out that the skin over the edematous portion of the body is not jaundiced and that the edema fluid is lacking in bile pigment, although it is present in the blood.

Etiology of Congestive Heart Failure.—Sexes are equally subject to congestive heart failure. Three-fourths of the cases are found in those over fifty years of age.

The onset of auricular fibrillation precipitates congestive failure in 60 per cent of cases. Of the cases of congestive failure associated with fibrillation, about half in my series are associated with mitral stenosis and half with myocardial disease from hypertension, arteriosclerosis, coronary disease. A very small percentage of cases of fibrillation are due to thyrotoxicosis. The 40 per cent of cases of congestive heart failure associated with regular pulse (or at least pulse with a dominant rhythm, some have extrasystoles) are divided between those with myocardial disease or strain from hypertension, arteriosclerosis, coronary disease (90 per cent). These may be called failure from loss of tone. The rest are associated with bundle block (conduction failure), syphilitic aortic disease (6 per cent), and thyrotoxicosis. Scattered cases are due to myxedema heart, beriberi heart, etc.

So summing it up, we may say that congestive heart failure is associated with:

	PER CENT
Mitral stenosis with fibrillation	30.0
Myocardial disease with fibrillation	30.0
Thyrotoxicosis with fibrillation	0.5
Myocardial disease with regular pulse	36.0
Syphilitic aortic disease	2.5
Conduction disease	0.5
Miscellaneous	0.5

Sodeman and Burch (Am. Heart J. 15: 22, Jan., 1938) point out that about half the time (55 out of 104 cases) congestive heart failure is precipitated by a sudden definite event. When the onset is gradual, prognosis and response to treatment are poor. The precipitating events they record are:

Exercise (20), infection (18), pregnancy (5), sudden rise in blood pressure (2), psychic trauma (2), hemorrhage (2), surgery (2), coitus (2), heavy meal (1), alcoholism (1).

The Pathologic Physiology of Congestive Heart Failure.—The clinician observing a patient with congestive heart failure comes to the inescapable conclusion that the impairment of circulation consists in the stagnation of blood, especially in certain areas. When, after death, he examines the organs under the microscope, he finds that the capillaries are dilated and full of blood

cells and the veins are distended beyond normal. Eyster and Middleton (Clinical Studies in Venous Pressure, Arch. Int. Med. 34: 228, 1924) have shown that in myocardial failure the peripheral venous pressure is increased roughly in proportion to the degree of compensation.

This is the great fundamental fact about congestive heart failure. Many explanations have been offered to account for it. They are often contradictory and confusing. I intend to review the evidence, but as we go through the maze, let us keep the fundamental fact firmly in mind.

Of course, a second fundamental fact is that the blood is in stasis because the heart muscle is too weak to keep it circulating. But just what the nature of this weakness is comprises the problem of circulatory failure.

In the days of my youth it was all very simple—the heart could not do its work because it had *dilated*. The fibers had weakened, lost tone, stretched out, could not fully contract, and the chambers did not empty. This was before the days of auricular fibrillation. When that condition was discovered, it was seen that the heart could not do its work because the auricular impulse was not strong enough to produce at regular intervals a full contraction of the ventricles. Looking at the statistics of the etiology of congestive failure we see that the two forms—one with a regular pulse and one with an irregular pulse—may well occur. Whether dilatation in the old sense actually occurs or whether it is better to call it loss of tone, I cannot say.

But it is obvious that the crucial thing that happens, whether in loss of tone, fibrillation or dilatation, is that the amount of blood thrust out by the ventricles is insufficient. It may be just sufficient for the body at rest, or just sufficient for some activity, but the heart muscle cannot meet sudden increased demands.

It is possible to measure the cardiac output experimentally, with a fair though not absolute degree of accuracy and uniformity. The methods depend upon the so-called Fick principle, announced in 1870 (Fick, A. Gesellsch. zu Würzb. 16: 1870), which depends on the comparison between the blood in the right and left ventricle for either oxygen or carbon dioxide content. If the arterial blood contains 18 volumes per cent of oxygen (18 c.c. of O_2 per 100 c.c. blood), and the venous blood as obtained from the right heart, 12 volumes per cent, each 100 c.c. of blood would gain 6 c.c. of oxygen in passing through the lungs. If the total oxygen used by the animal is 60 c.c. per minute, then 1,000 c.c. of blood must have been required to transport the oxygen, and this equals the cardiac output. In human experimentation on clinical patients, various modifications of this principle, such as comparing the CO_2 content of arterial and venous blood and the use of foreign gases, notably acetylene, have been used. While the results leave much to be desired both in uniformity and in convincingness, it is possible to say that in a man twenty-five years old, weighing 150 pounds, the cardiac output is about four liters per minute. This is spoken of as a cardiac index of 2.2.

Cardiac index varies with posture, activity (increase), sleep (decrease), temperature (increase with rise of temperature), psychic disturbances, men-

struation (increase pre- and post-menstrually), and altitude (in which there is first an increase and then as hemopoietic function comes into play, a decrease).

In valvular disease of the heart there is a decrease, though not marked in compensated cases. In mitral stenosis after auricular fibrillation supervened, the cardiac index was 1.2. After conversion to a more or less dominant rhythm, it increased. In all cases of congestive failure it is decreased.

So we add one other to make a triad of fundamentally proved phenomena in congestive failure—diminished cardiac output. Stasis of blood in the capillaries, increased venous pressure, diminished cardiac output.

We must try, however, to explain the mechanism or sequence of changes by which these phenomena result in congestive heart failure. The natural immediate conclusion is that called the *forward failure* hypothesis, and that was the dominant idea during the early part of the present century. It is as well stated in a series of quotations selected by Harrison:

From Sir James Mackenzie: "The symptoms of heart failure from deficient output of blood might be found in almost any organ did we possess the means of observing them. It so happens that one system which suffers early from an impaired blood supply is one which readily gives rise to distress. This is the respiratory system and it is the distress in breathing on response to effort which is usually the earliest sign of heart failure. As the heart failure proceeds the distress in breathing becomes more easily provoked until a stage is reached when it is present even when the body is at rest."

From Sir Thomas Lewis: "Breathlessness is to be ascribed to a deficiency in the flow of aerated blood to the head and neck; at first the deficiency is confined to those exercises in which normally the cardiac output is much above resting values; at last there is a deficiency in the physiologic quantity of aerated blood expelled by the heart while the body is at rest. . . . It is when the output at rest declines that blood begins to collect on the venous side and the patient begins to manifest signs of congested veins and, associated with these, enlargement of the liver, cyanosis, a high-colored and scanty urine, ascites, dropsy of the lower members, and congestion and edema of the lungs."

From Meakins and Davies: "Cardiac failure of this character is due to an incomplete ventricular systole as a consequence of which the circulation rate is greatly and progressively diminished until the amount of circulating blood is grossly insufficient to carry on the functions of the heart, kidneys, nervous system, and other important organs."

From Means: "The fundamental fault responsible for cardiac dyspnea is obviously to be found not in the nature of the blood but the rate at which it is pumped. . . . The important point is that the heart either because of increased work, fatigue or degeneration is unable to maintain an adequate rate of blood flow."

From Henderson, Haggard and Dolley: "The efficiency of the heart is nothing else than the volume of blood that it can pump in relation to the oxygen requirement of the body. This applies to the athlete, the man of sedentary habit and to the cardiac patient."

But the more one ponders this hypothesis, the more he becomes aware that it is not sufficient alone to account for increased venous pressure and capillary stasis. This has led to the "backward failure" or back pressure hypothesis of congestive heart failure put forward by Dr. Tinsley R. Harrison (*Failure*

of the Circulation, Williams and Wilkins, 1939). It is inherent in the "forward failure" hypothesis, as can be seen by considering the last part of the quotation from Sir Thomas Lewis above, viz:

"It is when the output at rest declines that the blood begins to accumulate on the venous side."

Harrison presents the backward failure hypothesis as follows:

"In its simplest form the 'back-pressure' theory may be summarized as follows: Overwork of the heart leads to enlargement, which usually is brought about by both hypertrophy and dilatation of those portions of the heart which are subjected to the increase in work. If dilatation of a chamber becomes extreme there results a rise in the pressure in the veins which supply the affected side of the heart. The increased venous pressure leads to congestion of the organs drained by these veins. Thus, in a patient with mitral stenosis there is hypertrophy and dilatation of the left auricle with an eventual increase in the pressure in this chamber. This results in increased pulmonary venous pressure and congestion of the lungs. Because the pulmonary arterioles have little or no 'tone' the pulmonary arterial pressure is also raised. The right ventricle now being subjected to overwork undergoes hypertrophy and dilatation. After a time the dilatation may become marked. Then a relative insufficiency of the tricuspid orifice may develop with a rise in the right auricular pressure. Even though the tricuspid valve remains competent the increase in pressure in the right ventricle would tend to offer resistance to the passage of blood from the right auricle. Consequently, a rise in pressure in the latter chamber occurs. Eventually the systemic venous pressure rises, and as a result the symptoms of 'right-sided' failure develop: venous congestion, engorgement of the abdominal viscera, edema and, in some cases, ascites and hydrothorax."

It will be appreciated that failure of the two chambers of the heart result in different phenomena of congestive failure: failure of the left ventricle results in back pressure on the lungs with dyspnea, and fluid in the alveoli; failure of the right ventricle causes back pressure in the liver resulting in enlargement and ascites, and in the extremities resulting in edema. The ventricles, however, do not often fail separately. Left ventricular failure alone with acute pulmonary edema in some form is more common than right ventricular failure alone. The muscular structure of the two ventricles is so continuous and interwoven that they both fail together in the vast majority of instances.

Anginal Heart Failure

The syndrome of angina pectoris is the only indication the practitioner has of disease of the coronary arteries. Specific physical signs are few. The diagnosis rests upon six considerations: (1) analysis of the patient's history of pain or heart discomfort; (2) interpretation of electrocardiographic tracings (see p. 808); (3) general signs of change in other arteries—examination of eye grounds, blood pressure, urinalysis, functional kidney tests, N. P. N. of the blood; (4) leucocytosis, fever, rapid blood sedimentation rate and other general signs of thrombosis; (5) pericardial friction as a sign of infarction; (6) signs of myocardial weakness consequent upon myocardial infarction (substitution symptoms).

The coronary arteries are subject to spasm, notably from emotion and the action of tobacco; they are subject to the thickening and intimal changes of arteriosclerosis, resulting in a narrowing of the lumen which makes them more susceptible to spasm, or at any rate makes the consequences of functional spasm and narrowing of the lumen more serious, and also renders them subject to thrombosis which may or may not result in myocardial infarction.

All of these conditions are associated with the pain called angina pectoris which varies as to location, character, duration, and radiation. It is a contradiction in terms to speak of painless angina (*angina sine dolore*), but coronary thrombosis and infarction can occur without pain. Pain is present in 72 per cent of all cases of infarction of the heart muscle. The pain is most frequently located over the left precordium (244 out of 290 cases), substernal next (38 out of 290 cases) and in the epigastrium, teeth, fingers, occiput alone in scattering numerical ratios. Its character is described as lancinating (132), dull (116), or of compression (45) in Kilgore's series (*J. A. M. A.* 87: No. 7, Aug. 14, 1926); or in Beau's series (*Ann. Int. Med.* 11: No. 12, June, 1938) which dealt with infarction alone, crushing pressure (44); squeezing, constricting, vicelike (29); choking, smothering, suffocating (18); sharp, stabbing, knifelike (11); sore, aching, dull (11); excruciating (7); burning (5). The onset is sudden in the midst of apparent good health in about 33 per cent, or preceded by symptoms of some left (33 per cent) ventricular failure or right (33 per cent) ventricular failure, such as dyspnea on exertion, weakness, cough, nocturia, orthopnea, ankle edema, indigestion, palpitation, paroxysmal nocturnal dyspnea. Most of the patients have not been very critical of their health, so these statistics will vary in proportion with different men.

The duration of the pain may be minutes, hours, or days; the longer the duration, the more likely is it to be due to infarction.

Radiation does not occur in 70 per cent of attacks; when present it occurs to left arm (23 per cent); both arms (13 per cent); both arms and shoulders (8 per cent); neck (10 per cent); jaw (1 per cent); back (1 per cent); occiput ($\frac{1}{4}$ per cent).

Mackenzie emphasized and dinned into the profession's memories the description of the pain of angina pectoris as first laid down by William Heberden:

"The pain is sometimes situated in the upper part, sometimes in the middle, sometimes at the bottom of the os sterni and more often inclined to the left than to the right side. It likewise frequently extends from the breast to the middle of the left arm. The pain sometimes reaches to the right arm as well as to the left, and even down to the hands." Mackenzie pointed out that the left arm distribution is to the inside of the arm.

Painless cases are frequent (see Davis: *J. A. M. A.* 98: 1806, 1932; Smith and Brink: *Minnesota Med.* 19: 346, 1936; Stenn: *Illinois M. J.* 68: 381, 1935). Dyspnea leads the list of symptoms, other than pain, heralding the onset of myocardial infarction. It occurs in 95 per cent of all such cases. Vertigo or syncope, is next, then fainting spells, then great weakness. Rapidly increasing congestive heart failure is nearly always superimposed. (See Stroud and

Wagner: *Ann. Int. Med.* 15: 25, July, 1941; and Pollard and Harvill. *Am. J. M. Sc.* 199: 628, May, 1940.)

Circumstances under which an attack of angina due to coronary occlusion is brought on are recorded for 930 attacks by Master, Dock and Jaffe (*Am. Heart J.* 18: No. 4, Oct., 1939) as follows:

TYPES OF ACTIVITY AT ONSET OF CORONARY ARTERY OCCLUSION (930 ATTACKS)

TYPES OF ACTIVITY	NUMBER	PERCENTAGE
A. Primary Activities (890 attacks):		
1. Sleep	198	22.3
2. Rest—lying down or sitting up	277	31.1
3. Ordinary mild activity	180	20.2
62, in home (dressing, standing, walking about, playing with children, talking, retiring, etc.); 33, in store or office; 14, sitting in car or train; 9, in doctor's office or in clinic; 8, doing light housework; 6, getting out of bed; 5, taking showers or bath; 5, getting out of bus or car; 5, playing cards; 4, attending a meeting; 4, sitting in a movie; 2, in a restaurant; 21, miscellaneous.		
4. Moderate activity (except walking)	76	8.5
35, working as laborers (painter, engineer, carpenter, baker, tailor, pressor, etc.); 16, driving car; 8, during bowel movement or straining at stool; 6, shopping; 2, coughing; 2, running upstairs; 2, during coitus		
5. Walking	141	15.8
107, in street; 11, upstairs; 6, after meals; 5, against cold wind; 4, uphill; 4, downstairs; 2, in snowstorm; 2, carrying ten pounds.		
6. Unusual or severe exertion	18	2.0
9, during or immediately after sport or games (football, swimming, dancing, skating); 5, lifting or moving a heavy load; 3, running for train; 1, after long automobile ride.		
B. Associated Factors (930 attacks):		
1. Meals	92	9.9
37, heavy meal; 33, ordinary meal; 22, light meal; 15, in sleep; 10, while walking.		
2. Excitement	52	5.6
13, gambling or playing cards; 8, during argument; 4, at movies; 3, news of deaths of relatives; 3, fright; 3, at wedding or banquet; 2, making speech; 2, during coitus; 1, at funeral; 13, miscellaneous (emotional upset).		
3. Surgical procedures	67	6.6
26, laparotomy; 20, genitourinary operation; 7, eye, ear, nose, or throat operation; 3, leg operation; 2, thyroidectomy; 1, thoracotomy; 1, tooth extraction; 1, incision of furuncle; 1, paravertebral block; 1, bronchoscopy.		
4. Infection	40	4.3
14, upper respiratory infections; 6, grippe; 4, cholecystitis; 2, peritonitis; 3, pyelonephritis; 4, pneumonia; 2, appendicitis; 2, sepsis; 3, abdominal suppuration.		
5. Miscellaneous	10	1.1
3, diabetic acidosis; 2, insulin injections; 2, trauma (1 fall on chest and 1 injury to eye); 2, smoking; 1, typhoid vaccine injection.		

Incidence.—Coronary artery disease is increasing in frequency, partly due to increased alertness or diagnostic acumen, partly due to numerical increase

in the old age groups. In 1920 the rate of hospital admission for coronary disease was 4 per 1,000; in 1931 it was 8 per 1,000. The higher the age group the higher the incidence of all forms of coronary artery disease. It is a curious and unexplained fact that males predominate in the incidence of angina pectoris. Based on autopsy material, the disparity is not so great; coronary artery disease is found in 34 per cent of males, 25 per cent of females (Levy, Bruenn, and Kurtz: *Am. J. M. Sc.* 187: No. 3, March, 1934), but the occurrence of the symptoms of an attack of angina or coronary thrombosis is 77.4 per cent for males and 22.6 per cent for females.

The age group of 45 to 65 produced two-thirds of all attacks. One-third occur before the age of fifty.

Coronary occlusion is rarely fatal before the age of forty. The mortality rate increases gradually up to the age of fifty-nine and then rises sharply.

The frequency of multiple attacks is the same in all age groups.

Hypertension occurs in more than half the men and four-fifths of the women.

Diabetes is a frequent accompanying or exciting condition, more in women than in men. Diabetes has a definitely bad influence on angina.

The personality make-up of angina patients is not of any consequence. The notion that anginal patients are "tense" is a myth. Of course, tenseness and liability to emotional upsets, especially bursts of temper, bring on spasm of the coronary arteries or narrow their lumen, but this is due to their anatomic condition. Hunt, Comstock and McClellan (*International Clin.* 3: 1940) found in a comparative study of two groups, one with, one without a history of angina, that the patients who suffered from angina pectoris tended to have a low blood pressure, to sleep poorly, and to be obese. There was no essential difference in background, mode of living, or habits of the two groups. The emotional make-up of the patients studied was strikingly similar, although 78 per cent of those who had angina had their attacks precipitated by emotion. More of the control group were nervous, tense, impetuous, apprehensive, etc., than of the anginal group.

The average duration of life from the first attack of angina was two years in Root and Graybiel's series (*Angina Pectoris and Diabetes Mellitus*, J. A. M. A. 96: No. 12, March 21, 1931) as compared to Mackenzie's average duration of 5.4 years. Root and Graybiel had an incidence of 210 cases of angina among 7,000 cases of diabetes, a ratio far above that of a nondiabetic group. Of course, the nature of the relationship is no mystery; diabetes in the middle-aged and elderly is simply an expression of arteriosclerosis in the islets of Langerhans.

Cardiac failure, either as an accompaniment or consequence of coronary thrombosis increased with age. (See Master, Dock and Jaffe: *Age, Sex and Hypertension in Myocardial Infarction Due to Coronary Occlusion*, *Ann. Int. Med.* 64: No. 4, Oct., 1939.)

Diagnosis and Nature of Angina.—The recognition of coronary artery disease based on autopsy records is successful in 15 per cent of all types of cases; slight sclerosis was successfully diagnosed in 10 per cent, moderate sclerosis,

7 per cent, calcification and stenosis in 16 per cent, and thrombosis in 43 per cent. (Levy, Bruenn, Kurtz, *op. cit.*)

What causes the symptoms of angina pectoris? The heart muscle and endocardium are notably without true sensory nerve supply. True afferent impulses giving rise to the sensation of cardiac pain leave the heart by cardiac sympathetic nerve fibers coursing to the cervical and upper dorsal sympathetic ganglia, passing to the spinal cord through the rami communicantes of the upper five thoracic nerve roots. By interrupting these upper thoracic rami communicantes, it is known as a matter of practical everyday surgery that the pain impulses are blocked and attacks of angina are not felt.

Huehard (*Traité chirurgie des maladies du coeur et de l'aorte* Paris, 1899) in 1899 was able to collect eighty theories of cardiac pain. Only three of these need be considered now:

1. Cardiac pain is due to decreased blood flow to a part or all of the myocardium, caused either by arteriosclerotic narrowing of the coronary arteries or spasm or thrombosis or any two or all of them.

2. Cardiac pain is due to the stretching of the acutely or chronically inflamed aorta or aortic ring. (This theory was espoused by Clifford, Allbutt, Wenckebach, and Vaquez.)

3. Cardiac pain is due to exhaustion of the heart muscle, either from defective blood supply or extensive damage of the heart muscle from other causes. (This theory was advanced and defended by Mackenzie.)

Few clinicians now consider the last two seriously, except as applied to special cases.

There is probably no doubt now among clinicians that the coronary arteries are the seat of the pain of angina. When Herrick in 1912 noted the direct association of anginal symptoms in patients with coronary thrombosis (who did not die as an immediate result of the thrombosis, which had been a stock form of teaching up to that time), the role of the coronaries in heart pang was made definite. Osler announced in his Lumleian lecture in 1912, "We are all united in the acceptance of the Jennerian view of the close connection of the lesions of the coronary arteries with the disease. Of the 17 necropsies of my list, 13 illustrated all the varieties of the lesions." Note that Osler did not say coronary *thrombosis*, which was Herrick's contribution, but coronary *lesions*.

The question then arises, is every case of angina due to coronary thrombosis? The clinical drift of late has been strongly in that direction. White (*Heart Disease*, p. 608) says, "Angina pectoris precedes coronary thrombosis in about half the cases and coronary thrombosis is one of the most striking complications of angina pectoris occurring in about 20 per cent of cases." It is easy to conceive that with a narrowing of the lumen of the coronary arteries, anything which raised the vasomotor tension—exertion, emotion, excitement, grief, tobacco—could cause sufficient spasm of the already narrowed arteries as to result in complete functional occlusion with consequent anemia of the myocardium, practically the same result as coronary occlusion without actual thrombosis. Clinically these are two quite distinct groups among

anginal cases—one we can term simply angina pectoris which occurs in the arteriosclerotic age with sudden onset of heart pain, which passes off rapidly, and the other, in the same group of cases, with the same sort of symptoms but accompanied by shock of varying degree, leucocytosis, perhaps fever, certainly prostration sufficient to enforce inactivity for some days or weeks. The latter are the cases of thrombosis.

The further question arises as to whether there is such a thing as functional angina—heart pain quite similar to organic coronary disease that occurs in the young, usually induced by excessive smoking. In other words, is there a “tobacco angina”? Opinion is somewhat divided on this question. “It appears from this study that neither the use of nor abstinence from tobacco or alcohol plays an important role in the genesis of angina pectoris.” (White and Sharber: Tobacco, Alcohol and Angina Pectoris, J. A. M. A. 102: No. 9, March 3, 1934.) Moschocowitz (Tobacco Angina, J. A. M. A. 90: No. 10, March 10, 1928) concludes “Tobacco smoking may cause symptoms closely resembling the angina pectoris of coronary or aortic disease. The pain of tobacco heart is usually more intense and of longer duration than that of true angina and is usually accompanied by slight or no disturbance of heart function.”

My personal experience inclines me strongly to the belief that tobacco angina is a true entity. I have recollections of several young men in college who, on indulging in a strong pipe, had precordial pain so severe as to make them roll on the floor. Several of them are still known to me after nearly forty years, hale and well, free from angina even though they still smoke, and not any more obviously subjects of hypertension or arterial disease than the average of that age group. I can only think that their coronary arteries, when young and more or less early in their experience with tobacco, were more spastic.

White and Wood (J. A. M. A. 81: No. 7, 1923) have classified heart pains as follows:

1. Simple fatigue pain:

- (a) Chronic hypertension.
- (b) Aortic stenosis or regurgitation.
- (c) Mitral stenosis.
- (d) Pulmonic stenosis—congenital heart disease.
- (e) Adherent pericarditis.
- (f) Paroxysmal tachycardia or paroxysmal auricular fibrillation or flutter.
- (g) Permanent auricular fibrillation or flutter with high ventricular rate.
- (h) Permanent coronary narrowing due to arteriosclerosis.

2. Nervous heart pain, including effort syndrome.

3. Paroxysmal heart pain (probably of coronary disease or irritability), the so-called true angina pectoris.

4. Pain of coronary thrombosis.

5. Aortic pain, of syphilitic aortitis and aneurysm.

6. Pain of pericarditis.

Frequently, combinations of these factors occur.

In assessing the relative value of the various procedures in diagnosis, it is evident that the history is by all odds the most important single element. The

old dogmatic rule which described the cause of onset of angina and its rhythm, i.e., "exertion, pain, rest, relief means real angina," "rest, pain, exercise, relief means functional angina," needs some modification in view of the intense interest focused on coronary thrombosis in the last two decades. Master, Dock and Jaffe (*Am. Heart J.* 18: No. 4, Oct., 1939) found that the activities associated with the onset of 1,440 attacks of coronary artery occlusion were: sleep, 22.3 per cent, rest, 31.1 per cent, mild activity, 20.2 per cent, moderate activity, 8.5 per cent, walking, 15.8 per cent, unusual exertion, 2 per cent, excitement—argument, gambling, drinking, fight, bad news—was a precipitating factor in 5.6 per cent. Smoking was associated with onset in only 2 cases—a very small percentage. The attacks were evenly distributed throughout the twenty-four hour period, 376 occurring from 7 A.M. to 7 P.M. and 346 from 7 P.M. to 7 A.M. (in those cases where the time was recorded). "It is important," write these authors, "to distinguish clearly between an attack of angina pectoris and one of coronary artery occlusion. The former is definitely related to exertion, meals, excitement, cold. In an attack of angina pectoris the patient is usually incapacitated for only a few minutes and is as well after the attack as before. When coronary artery occlusion occurs, however, the patient suffers severe prolonged pain, may collapse, and develops signs of diminished cardiac output and heart failure. If the attack is survived, physical incapacity persists for weeks and months."

Literature, both medical and secular, is so full of descriptions of every variety of the attack of angina that the nosologist need never lack for graphic material. Dr. Henry F. Stoll (*Am. Heart J.* 9: No. 3, Feb., 1934) called our attention to a very early recording of a case in the person of an itinerant philosopher, eighty-two years of age, who was entertained during his wanderings by the blacksmith of a small village with a feast, of which one dish particularly pleased the guest of honor so that he ate a great deal of it. Immediately after the meal he became faint and had violent pain. In order not to spoil the festivities, he resumed his journey, but had to stop on account of weakness and pain. He must have been shocked because he called repeatedly for water. A few hours later he died. He was the son of a wealthy man and had been brought up in luxury, but became convinced of the futility of the life of pleasure and took to poverty and the open road, preaching a form of mysticism. He subsisted on a poorly balanced diet which was inadequate in protein, and toward his later years he varied this by dining quite elaborately at the invitation of wealthy nobles, and once, just before his fatal indulgence with the blacksmith, at the house of a courtesan. After this dinner he also became ill. He was constitutionally of the pyknic type, especially prone to coronary disease. His name was Gautama Buddha.

The early record of the Earl of Clarendon (1609-1674), written by his son (*Life of Edward, Earl of Clarendon, 1759*), describes both the symptoms and constitutional traits of angina pectoris.

"He was still and constantly seized by so sharp a pain in the left arm for half a quarter of an hour or near so much, that the torment made him pale (whereas he was otherwise of a very sanguine complexion) as if he were dead;

and he used to say 'that he had faced the pangs of death, and he should die in one of those fits.' As soon as it was over, which was quickly, he was the cheerfulest man living; ate well, walked, slept, digested, conversed with such a promptness and vivacity (for he was the *omnifarium doctus*) as hath been seldom known in a man of his age."

John Hunter's historic case was described by Everard Home:

"These symptoms increased in violence at every return and the attack which was the most violent came on one morning about the end of April and lasted above two hours; it began as the others had done, the pain become excruciating at the apex of the heart, and the left arm could not bear to be touched, the pain quite exhausted him and he sank into a swoon or doze which lasted about ten minutes, after which he started up without the least recollection of what had happened. I never saw anything equal to the agonies he suffered, and when he fainted away, I thought him dead. . . . It is a curious circumstance that the first attack of these complaints was produced by an affection of the mind, and although bodily exercise or distention of the stomach brought on slighter affections, it still required his mind to be affected to render them severe; and as his mind was irritated by trifles, these produced the most violent effects on the disease. His coachman being beyond his times, or a servant not attending to his directions brought on the spasms, while a real misfortune produced no effect."

It is always valuable to hear a physician's description of his own case. Dr. Fletcher Ingals has left us the following classical description:

"The pain in angina is usually paroxysmal, rarely a steady grind. It may increase from slight to extreme anguish. It may be short and sharp for an instant only, but it usually lasts from several minutes to half an hour or more, and occasionally continues much of the time for days. Sometimes it is confined to the chest; at other times it radiates to one or the other arm, rarely to the thigh. It is located sometimes in the neck and occasionally in the throat or larynx. It is sometimes felt on the radial side of the arms and may run down to the thumb. In some erratic cases, the pain may be confined to the periphery, as to the palm of the hand, or to a finger, and in one of my cases it was often felt in the rim of the ears. It may also be felt in the epigastrium, the apex of the heart, or the abdomen. There are some cases in which the patient has a horror but an absence of pain. Angina without pain (*angina sine dolore*) is comparatively rare, but may be the cause of death in many of those who die suddenly without symptoms.

"The heart pain in angina pectoris is usually said to be precordial; but in reality it is nearly always felt at the upper part of the sternum over the aorta. In one case that I have observed, it started in the region of the left subclavian and was so constant that the patient, a physician, believed there was an aneurysm of this artery. With 'X' it usually started over the brachial artery in the middle of the right arm.

"Immobility from a fear to move, or a feeling that one cannot move, is a common symptom. The feeling of impending death or of horror is not a reasonable apprehension, nor yet a fright, but an organic sensation, a feeling as though everything was going and nothing mattered. It may occur in only one or a few of the attacks and sometimes is altogether absent." (Ingals, E. Fletcher, and Meeker. William R.: *Angina Pectoris*, J. A. M. A. 70: No. 14, April 6, 1918.)

Physical examination except to note that the patient is pale, immobile, or in shock is strikingly negative. The pulse usually does not change. There are no striking changes in the heart sounds. Fever comes later.

The electrocardiographic signs are quite reliable and have been confirmed and worked out in great detail (see p. 808 for full discussion).

Red cell sedimentation time is a very valuable rough determinant of the extent of tissue damage. It is likely to be normal in angina and rapid in coronary thrombosis (see Rabinowitz, Shookhoff, and Douglas: *Red Cell Sedimentation Time in Coronary Occlusion*, *Am. Heart J.* 7: No. 1, 1931).

The blood pressure, according to Levine and Ernstene (*Am. Heart J.* 8: No. 3, Feb., 1933), rises during the period of pain and falls afterward, but their observations are vitiated by the fact that most of their patients had nitroglycerin. Gager (*J. A. M. A.* 84: No. 23, June 6, 1925) thought that if myocardial infarction occurred, the blood pressure fell and this fall was significant of the existence of infarction, which agrees with my experience.

Differential Diagnosis.—In the days before acute coronary thrombosis was described as an entity, the tendency was to call real attacks by another name—ptomaine poisoning, acute indigestion, acute dilatation of the heart, acute heart failure, cerebral hemorrhage or thrombosis, perforating duodenal or gastric ulcer, pancreatitis, gall bladder disease were some of these which were and still are used as the label for an attack of actual coronary thrombosis. Nowadays, however, the tendency is to label any acute pain anywhere near the heart or epigastrium coronary thrombosis. Such mistakes may be quite embarrassing; a grave prognosis becomes a joke to make the physician look foolish in after days. The most frequent class of cases in which mistakes are made are the neuroses, malingering, and imitative hysteria. Newspaper reading furnishes the susceptible individual with plenty of material for self-diagnosis. Some of the most satisfactory therapeutic results come from the ability to persuade a susceptible individual that he did not actually have an acute "heart attack." Sudden onset of an arrhythmia may cause a misinterpretation. Aortitis and dissecting aneurysm produce similar pain. Pleurisy, the onset of pneumonia, massive pulmonary collapse from obstruction of a bronchus from carcinoma or foreign body, pulmonary infarction, spontaneous pneumothorax, are among the pulmonary diseases that may be considered. Herpes zoster, before the eruption, is a troublesome imitator. The lancinating pains or gastric crises of tabes are also. Disturbances of the bones of the chest, arthritis of the costochondral junctions, or slipping rib syndrome, radiculitis from vertebral hypertrophic arthritis (Dr. Irons mentions a case of fractured vertebra which had been diagnosed and treated for acute coronary thrombosis) all have a record of error in practice. Acute abdominal disease—gall bladder especially (see Faulkner, Marble and White: *The Differential Diagnosis of Coronary Occlusion and of Cholelithiasis*, *J. A. M. A.* 83: No. 26, Dec. 27, 1924) and less frequently perforated ulcer. Hamman (*Bull. Johns Hopkins Hosp.* 64: No. 1, Jan., 1939) described spontaneous mediastinal emphysema which in his experience was several times mistaken for acute coronary thrombosis. It is apparently caused by the same pathologic condition which may

result in spontaneous pneumothorax—an emphysematous bleb on the surface of the lung. The symptoms are sudden, excruciating pain under the sternum, radiating to the back of the neck and shoulders; it is not accompanied by shock, temperature, leucocytosis. There may be an accompanying pneumothorax. When the air reaches the neck, the diagnosis is easy. The condition is precipitated by coughing, an asthmatic attack, the heart in labor, trauma, etc. The x-ray will usually reveal the true condition (see Stryson: *New England J. Med.* 225: No. 23, Dec. 4, 1941). (See also Herrick: *On Mistaking Other Diseases for Acute Coronary Thrombosis*, *Ann. Int. Med.* 11: No. 12, June, 1938, and Herrick: *Diagnostic Mistakes in Coronary Thrombosis*, *J. M. Soc. New Jersey* 32: No. 10, Oct., 1935.)

Typical attacks of angina occur in young individuals with aortic insufficiency. (Ernstene and Schneider: *Am. J. M. Sc.* 202: No. 5, Nov., 1941.)

Anemia of any type, if severe, may produce anginal attacks probably by the mechanism of myocardial ischemia. In pernicious anemia, heart pain, especially on exertion, is quite familiar. (Herrick: *Angina Pectoris and Severe Anemia*, *Am. Heart J.* 11: No. 4, April, 1927.)

Hiatus esophageal hernia, especially small hernias, are sufficiently frequently mistaken for angina that Dr. Charles M. Jones was able to collect 128 cases (Jones: *Hiatus Esophageal Hernia With Comparison of Its Symptoms With Those of Angina Pectoris*, *New England J. Med.* 225: 25, Dec. 18, 1941).

The prognosis of the anginal syndrome depends more on the establishment of the diagnosis of thrombosis than on anything else. White and Bland (*Am. Heart J.* 7: No. 1, Oct., 1931) found that of five hundred patients with angina, two hundred and thirteen were dead, the average duration of life being 4.4 years. Death was attributed to heart failure in 82 per cent, and among two hundred patients with coronary thrombosis, one hundred and one were dead, with an average duration of life of 1.5 years. Ten years later Drs. White and Bland (*Tr. Am. Clin. & Climatol. A.* 56: 1941) reported again on what had happened to these same patients—the survivors of course—during that interval. Two-thirds of those who survived the initial attack died within ten years, thirty in the first year, and the others with relatively little variation year by year thereafter. Fifty patients survived the first decade in reasonably good condition—approximately one-third, which is certainly more favorable than is generally realized. Of that group one-third completely recovered, one-third were limited by repeated attacks of angina, and one-third by dyspnea plus angina. Sex has some significance in prognosis: in the series 84 per cent were men, 16 were women; the women succumbed immediately (within four weeks) twice as often as the men, and few women survived the ten-year period. Age at onset influenced mortality in that those who succumbed to the immediate attack were ten years older than those who survived. Hypertension also had an effect, few hypertensives surviving the ten-year period.

Seventy-two autopsy cases of myocardial infarction, in which the age of the infarct could be accurately determined, were studied by Mallory, White and Saleedo-Salgar in order to ascertain the speed of healing of the infarcts.

Necrosis of muscle and infiltration by polymorphonuclear leucocytes are the important features of the first week. Removal of the necrotic muscle and replacement by connective tissue predominate during the next five weeks. Beginning at about the second week, the newly formed connective tissue lays down increasing amounts of collagen. This collagen gradually increases in amount and becomes more dense. This process reaches a maximum at about three months, and thereafter very little change takes place.

The age of an infarct can be judged fairly accurately from the histologic picture during the first three weeks. After this the estimation is not very accurate. (The Speed of Healing of Myocardial Infarction, Mallory, G. Kenneth, White, Paul D., and Salcedo-Salgar, Jorge: *Am. Heart J.* 18: 647, 1939.)

Diseases of the Myocardium

Hypertrophy and Dilatation.—The heart in an average adult male weighs 300 grams; female, 250 grams. With hypertrophy of the musculature this may be increased to over a thousand grams. There are individual records of hearts weighing 1,700 and 2,500 grams. Hypertrophy may affect one chamber preponderantly: in aortic disease and hypertension the left, in mitral disease and obstruction of the pulmonary circulation, the right ventricle. But usually the heart chambers hypertrophy simultaneously and more or less equally. Hypertrophy consists in an enlargement of individual muscular fibers, not an increase in their number.

Hypertrophy is the most delicate index of organic heart or hypertensive disease. Methods of determining it are recorded above under physical examination and in the chapter on the x-ray.

Physiologic hypertrophy occurs after laborious occupations or athletics. Pregnancy produces an apparent hypertrophy due to the high diaphragm and displacement of the heart. Athlete's heart is a somewhat debatable subject. Lee, Dodd and Young (*Boston M. & S. J.*, Sept. 30, 1915) found some hypertrophy in men who had done two years of competitive rowing. But there was very little difference between them and men who had been rowing four or ten years. Whether this hypertrophy leads to dilatation and heart failure in early middle age is very doubtful.

Dilatation follows hypertrophy. Theoretically it occurs when the hypertrophied heart can no longer do its work. Actually degenerative arterial changes most often initiate the heart failure called dilatation. Nearly always a more exact physiologic description can be arrived at to explain heart failure, rather than dilatation—i.e., auricular fibrillation, myocardial infarction, heart block, etc. Acute dilatation in a surgical operation was found by Levine in a series of nine cases to be actually auricular tachycardia in three, auricular fibrillation of sudden onset in four, and paroxysmal auricular flutter in two.

Cor pulmonale is the designation given to preponderant right ventricular hypertrophy due to obstruction or high pressure in the pulmonary circulation. Sometimes called "emphysema heart," the term is too restricted and White and Brenner in the first communication which focused attention on the sub-

ject (New England J. Med. 209: 1261, 1933) suggested the more acceptable term *cor pulmonale*. It is noted in about one per cent of cases of organic heart disease.

The etiologic factors are variable. Any cause which narrows the arterioles and capillary bed of the pulmonary circulation tends to produce it—emphysema, tracheal or bronchial stenosis, tuberculosis, chest and spinal deformities (Boas: *Cardiovascular Complications of Kyphoscoliosis*, Am. J. M. Sc. 166: 89, 1923, and Edeiken: *Effect of Spinal Deformities on the Heart*, Am. J. M. Sc. 136: 99, 1933) Ayerza's Disease (pulmonary arteriosclerosis). Aneurysm of the pulmonary artery has been described as a cause (Garvan and Siegel: Am. J. M. Sc. 198: No. 5, Nov., 1939). Even pulmonary infarction and multiple pulmonary metastases produce a form.

Classification of *cor pulmonale* has been made into the primary and secondary forms. The primary form is divided into the following varieties: acute, due to pulmonary embolism, infarction, and possibly pneumonia would be included: subacute, due to pulmonary metastases from gastric or breast cancer and obstruction of the pulmonary arterioles with metastatic plugs with secondary arteriolar thrombosis (Mason: Arch. Int. Med. 66: No. 6, Dec., 1940); and chronic, due to pulmonary stenosis, pulmonary endarteritis, pneumoconiosis (Thompson and White: Am. Heart J. 12: 641, Dec., 1936), emphysema, bronchiectasis, tuberculosis (Ackerman and Kasuga: Am. Rev. Tuberc. 43: No. 1, Jan., 1941), collapse therapy and possibly bronchial asthma. The secondary form is secondary to mitral disease and left-sided hypertrophy. (Brill: *Various Types of Cor Pulmonale*, Ann. Int. Med. 13: No. 3, Sept., 1939.)

Pathology.—There is first hypertrophy of the cells of the right ventricle and then dilatation. The right auricle and pulmonary artery are secondarily dilated.

Diagnosis.—There are no symptoms until the ventricle begins to fail. The pulmonary conditions produce dyspnea and cyanosis. With right ventricular failure, congestion of the liver, gastrointestinal tract and extremities occurs. Pain and palpitation are rare. Enlargement of the right ventricle should be made out on the x-ray. There is often a pulmonary systolic murmur. The jugular veins are engorged and sometimes pulsating. Arrhythmias are uncommon. The electrocardiogram shows an increase in amplitude of P_2 and 3 and a low or iso-electric P_1 . (Ippolito and Reinstein: *The Auricular Electrocardiogram in Chronic Cor Pulmonale*, Bull. New York M. Coll., Flower and Fifth Ave. Hosps. 4: No. 1, May, 1941.) Systemic blood pressure is low or unaffected.

The importance of recognizing the condition, I take it, is to determine whether a given patient's dyspnea is due to the pulmonary condition or to heart failure.

Chronic myocarditis is either the fibrous remains of a healed acute myocarditis or a healed infarct or some form of degeneration like fatty heart. Can it be diagnosed? Cabot was quite emphatic that it could not. "I have maintained for many years that the diagnosis of myocarditis is impossible

during life. . . . The use by H. A. Christian and others of the term myocarditis when there is clinical evidence simply of an enlarged and weakened heart seems to me unjustifiable. Only in the infarctive subgroup of cases can the diagnosis be often reasonably suspected during life. Some such suspicion may arise in any case of angina pectoris, especially when it occurs in elderly men." Fifty-two per cent of the cases in Cabot's series diagnosed during life as chronic myocarditis had no such lesion at autopsy, and in only twenty-two per cent did the clinical and pathologic diagnosis agree. Christian (*Chronic Myocarditis*, J. A. M. A. 70: No. 25, June, 1918) on the contrary states: "In my own experience from a clinical study of the patient there are few conditions in which we make mistakes so seldom as in this group of cases. Before necropsy I can say of any of them: 'This is a case of chronic myocardial insufficiency without organic valve lesion.'" These differences are largely a question of definition.

Diagnosis is possible with certainty only when the degenerated area lies in a conduction pathway, or near an impulse zone. If it is in a silent region there are no characteristic signs or symptoms. This is not the chronic myocardial insufficiency to which Christian refers. Cabot limited his definition by saying that myocarditis is rarely the cause of congestive heart failure. "It is usually associated with cardiac hypertrophy, but since such lesions as chronic nephritis are also present, we have no evidence that the myocarditis is the cause of the hypertrophy."

Forms we must emphasize:

Rheumatic Myocarditis.—The myocardium is probably affected quite as often in the course of rheumatic fever as the endocardium or pericardium. The characteristic pathologic histology of the myocardium in rheumatic fever consists in the presence of Aschoff's bodies. These are rounded globular fusiform or spindle-shaped inflammatory nodules located in the interstitial tissue in close relation to the coronary arterioles. They are sometimes large enough to be seen on gross inspection. They are considered to be specific granulomata of rheumatic infection. They occur in the acute stage and tend to disappear with the subsidence of the acute stage. Their incidence has been reported from 32.1 per cent (Libman: J. A. M. A. 80: 813, 1923) to 87.5 per cent (Mayer: Bull. Johns Hopkins Hosp. 36: 97, 1925). They may infiltrate the auriculoventricular ring or aortic ring and cause regurgitation from dilatation, or around the coronary arterioles (peri-adventitial) or some distance away from vessels, or in the conduction system (Coombs: *Rheumatic Heart Disease*, Wm. Wood & Co., 1924).

Diphtheria may produce diffuse and severe myocardial degeneration. Deaths not due to tracheal obstruction in diphtheria can be ascribed to the myocardial degeneration, strictly speaking, rather than to toxemia. Conduction changes, high grade heart block, vomiting, hepatic engorgement, a change in the quality of the first sound and gallop rhythm are the signs (See Warthin: *Myocardial Lesions in Diphtheria*, J. Infect. Dis. 35: 32, 1924; Edmunds Johnston: *Circulatory Collapse of Diphtheria*, J. A. M. A. 90: 441, 1928; and Smith: *Observations*

of the Heart in Diphtheria, J. A. M. A. 77: 10, 1921; Loth: The Heart in Diphtheria, Arch. Int. Med. 31: No. 5, May, 1923).

Death of diphtheria patients from circulatory failure have been ascribed to different causes, i.e., fall of blood pressure, shock, and stagnation of blood in splanchnic areas by Romberg; poison of the peripheral vasomotor nerves by Friedman; degeneration of the vagus nerve by Veronese; suppression of the suprarenal secretion by Abramson. Ch'in and Huang (Myocardial Necrosis in Diphtheria, Am. Heart J. 22: No. 5, Nov., 1941) show convincingly by a careful study of their own case and a general review of the literature that it is usually due to a profound myocardial necrosis much more serious than the cloudy swelling described by Loth or the parenchymatous or hyaline degeneration of other authors.

Syphilitic Myocarditis.—Clawson (Am. J. M. Sc., Nov., 1924) stated that "luetie myocarditis" is rare. Warthin (Am. Heart J. 1: No. 1, Oct., 1925) thought it was very common, at least so far as pathologic histology is concerned. "In my own experience in Michigan," he wrote, "syphilitic cardiovascular lesions are very common, and are more frequently associated with cardiac incompetency than is coronary disease or streptococcus, rheumatic, diphtheria or typhoid myocarditis." He described eight cases of sudden death due to exacerbation of a previously latent syphilitic myocarditis. The lesions were those of latent syphilis with fibrosis, with more recent infiltration of lymphocytes and plasma cells, but with numerous polymorphonuclear leucocytes. Shortness of breath and cyanosis, vague precordial distress, palpitation, dizziness, marked fatigue and epigastric distress, were the symptoms. Few clinicians would agree that Warthin established his claims. In syphilis the myocardium is usually silent.

Influenza.—The involvement is not so severe or fatal as in diphtheria. The evidences of cardiac involvement are likely to appear sometime after the acute period is over. The signs and symptoms depend upon the area and the extent of area involved. (See Hyman: Post-influenzal Disturbance of the Heart, New York State Jour. 1926; Hamburger and Priest: Heart Following Acute Respiratory Infection, Am. J. M. Sc. 166: 629, 1923.)

Fiedler's Myocarditis.—Fiedler (Ueber akute interstitielle Myokarditis, Centralbl. f. innere Med. 21: 212, 1900) in 1889 described cases of what is called acute isolated myocarditis. Scott and Saphir (Am. Heart J. 5: No. 2, Dec., 1929) first directed attention to this condition in America. Simon and Wolpaw (Arch. Int. Med. 56: No. 6, Dec., 1935) collected forty-six cases from the literature and added one of their own.

Acute isolated myocarditis is characterized by the occurrence of destructive histologic lesions. The myocardium shows a diffuse infiltration of the interstitial tissues by lymphocytes, mononuclear cells, and to a lesser extent, by polymorphonuclear leucocytes, eosinophile and plasma cells. Numerous fibroblasts and new blood vessels may be seen. Occasionally small areas of necrosis are found in the muscle fibers themselves. The same heart may show varying stages of lesions ranging from cellular infiltration to fibrosis. The

lesions are more likely to be isolated and spotted, not diffuse, and to involve mainly the left ventricle. The endocardium and pericardium are seldom involved.

The etiologic agent is unknown; possibly several infections may cause the condition. Scott and Saphir found cases associated with phlegmon of the foot, carbuncle, burn, abscess of the neck, gonorrhea, upper respiratory infection, influenza, rheumatism, and pneumonia. Syphilis or positive Wassermann was present four times in eighteen cases (Hansmann and Schlisken).

The symptoms are those of rapid myocardial failure. The signs, as in other forms of acute myocarditis, depend on the location of the lesions. Electrocardiograms may change in appearance from day to day, showing conduction changes, prolonged P-R interval, bundle block, sinus arrhythmia, premature contraction, etc., and this changeableness is notably the most characteristic diagnostic sign.

Hansmann and Schenken (*Am. Heart J.* 15: No. 6, June, 1938) listed the clinical features as follows: age: 21-53; duration: 1-150 days; mode of onset: sudden, 50 per cent, restlessness, 50 per cent, dyspnea, 8.5 per cent, cyanosis, 75 per cent, precordial pain, 70 per cent, weakness, 70 per cent, arrhythmia, 35 per cent, frothy sputum, enlarged heart, fever, leucocytosis, rapid heart, sweating, abdominal pain scattering.

Calcification of the heart is not common, but occurs and can often be made out by x-ray examination. I remember a fellow practitioner who had an office in the same building with me. As he approached his seventieth birthday, he became noticeably dyspneic. His son tried to persuade him to let me examine him, but he would not have a stethoscope laid on his chest or go near an electrocardiographic apparatus. At autopsy nearly the entire auricles, and intra-ventricular septum were a mass of calcified matter. Scholz's patient was seventy-four years old and died of an incarcerated hernia. (Scholz: *Calcification of the Heart*, *Arch. Int. Med.* 34: No. 1, July, 1924.)

Cardiac aneurysm is not so rare as usually believed. It occurs at necropsy in about 9 per cent of cases of cardiac infarction. It may be syphilitic, mycotic, rheumatic, congenital, or the result of trauma, but by all odds the commonest cause is cardiac infarction following coronary thrombosis. In some cases the aneurysm is saccular, communicating with the ventricle by a definite neck, but more often an old infarct tends to form a pouch or bulge which is not sharply demarcated from the main ventricular cavity. In about half the cases the aneurysm occurs at the apex, from the anterior wall of the left ventricle in a fifth, from the posterior wall of the left ventricle in a tenth; some involve both apex and wall (anterior or posterior) and sometimes just below the aortic orifice (not due to coronary disease).

Since the advent of radiology the diagnosis can be made in a good proportion of cases. Parkinson, Bedford and Thomson (*Quart. J. Med.*, New series, 7: 1938) made the diagnosis three times in five cases, all of which came to necropsy. In the presence of a history of a coronary episode, at an average interval of seventeen and one-half months (may be as low as two weeks), the physical signs show increased area of cardiac dullness and pulsation, with a

very forceful apex beat, a bruit de galop, and systolic or double murmur at the apex. The typical pulsation of cardiac aneurysm is described as distinct from the apex beat. Paroxysmal tachycardia and other pulse abnormalities occur. The clinching signs are radiologic, viz.:

- (1) Enlargement of the left ventricle with deformity of its contour.
- (2) A localized protuberance inseparable from the heart shadow, in rotation of the patient.
- (3) Abnormal or absent pulsation of the aneurysmal zone.
- (4) Evidence of adhesions between the heart and the chest wall or diaphragm.
- (5) Calcification of the wall of the sac or its contained clot.

Thyrotoxicosis if long continued eventually results in a curious fragmentation of the myocardium described by Goodpasture (J. A. M. A. 76: No. 23, 1921). This, however, is very uncommon. McEachern and Rake found in twenty-seven patients dying of hyperthyroidism that fourteen had no discoverable change in the myocardium, and there was only slight change in eight. Gotta (Arch. Int. Med. 61: 858, June, 1928) showed that hyperthyroidism per se does not cause enlargement of the cardiac area. Hyperthyroidism is put down as one of the main causes of auricular fibrillation, but it is a factor in less than 1 per cent of all cases of auricular fibrillation. Magee and Smith (Am. J. M. Sc. 189: 683, May, 1935), in studying 210 cases of auricular fibrillation associated with hyperthyroidism, found that age played an important role. This would seem to indicate that in a heart predisposed by arterial disease and age toward fibrillation, hyperthyroidism is a bad influence in that it is likely to precipitate fibrillation or failure. Congestive failure usually occurs with the onset of fibrillation but can occur without fibrillation. To anyone watching a hyperthyroid heart, the real wonder is that the heart can take the pounding it gets so long.

Myxedema Heart.—Zondek in 1918 and Fahr in 1925 described myxedema heart, which must fulfill two requirements to qualify as such: (1) general enlargement and dilatation of both right and left chambers of the heart which (2) must return to normal size under thyroid medication. The myxedema patient is usually in the hypertensive arteriosclerotic age zone, and it would be natural to suppose they had some evidence of heart disease. Myxedema heart has provoked considerable discussion pro and con as to whether it is an entity. Cases fulfilling the above requirements are certainly rare.

Beriberi Heart.—Myocardial changes with congestive failure have been known in the Orient for some time. "Wet" beriberi indeed, as I understand it, is nothing more than the congestive heart failure form of the disease. In 1936 Soma Weiss and Wilkins (Tr. A. Am. Physicians 51: 341, 1936) described cases occurring in Boston. Weiss, Haynes and Zoll (Am. Heart J. 15: 206, Feb., 1938) showed that thiamine deficiency would produce cardiovascular changes in animals which were restored to normal on resumption of thiamine feeding. The clinical picture of occidental beriberi is not specific. The typical patient is a male, 30 to 50 years of age, with a history of alcoholism and ex-

posure. There is edema, usually arterial degeneration and improvement on rest with the exhibition of thiamine (Weiss: Occidental Beriberi With Cardiovascular Manifestations—Its Relation to Thiamin Deficiency, J. A. M. A. 115: No. 10, Sept. 7, 1940).

Diseases of the Pericardium

The pericardium may be the site of inflammation or trauma (usually wounds), very rarely neoplastic disease, occasionally degeneration (most often calcification following inflammation), and subserous hemorrhage due to cardiac infarct (the so-called uremic pericarditis).

Ten per cent of consecutive autopsies, as reported by MacLachlan (Am. J. M. Sc. 162: No. 5, Nov., 1921), showed pericarditis: 5 per cent were acute, 4 per cent were chronic, and 1 per cent tuberculous. Acute pericarditis was present in 7 per cent of cases of acute lobar pneumonia, probably as a terminal phenomenon. The principal etiologic factor in pericarditis is acute rheumatic fever.

The diagnosis of pericarditis is not made ante mortem nearly as often as this. And, despite oracular warnings and deplorings that are sent out periodically in the medical press, the statistics will probably not improve much because the disease is inherently impossible of diagnosis in the great majority of instances. Thus Hermann and Musser (Am. Heart J., 1928) were able experimentally in dogs to produce at will the various types of chronic fibrous pericarditis, but, even knowing the pericarditis was present, discovered no pathognomonic clinical signs, except when the parietal pericardium was anchored to the intercostal muscles. Nor was the electrocardiogram of value.

Acute fibrinous pericarditis may be suspected whenever an acute attack of rheumatic fever occurs. Between suspicion and proof, however, there yawns a great gulf. Whether the pericardium produces pain or not, especially whether it produces local pain, has engendered the greatest variety of clinical opinion. Allbutt wrote: "The patient complains of a dull, wearisome ache, rather than an acute pain. Not infrequently there is pain on swallowing." Mackenzie wrote: "Dry pericarditis is essentially a painless complaint. This curious painlessness has long puzzled me." Hirschfelder wrote: "In simple fibrinous pericarditis precordial pain is the most striking symptom."

When referred pain is considered, there is a little more agreement. Abdominal pain is frequent, and Friessell and Kay (Am. J. M. Sc. 163: No. 1, Jan., 1922) reported cases where the clinical picture looked like appendicitis: this is certainly not rare. Allbutt, as a result of clinical observation, called attention to the pain being "reflected to the neck and shoulder blade or shoulder." Capps proved this experimentally (Arch. Int. Med. 40: No. 5, Nov., 1927) doing paracentesis of the pericardium at the fifth and sixth interspace which elicited pain in the neck along the trapezius ridge: paracentesis at the fourth interspace elicited no pain. Pressure on the pericardial investment of the heart produced no pain. When the central portion of the diaphragmatic pleura is irritated it causes pain in the neck. The inference is that the phrenic nerve supplies the central diaphragm and the fibrous pericardium with fibers that carry afferent

impulses. "The presence of pain with pericarditis usually indicates the involvement of tissues outside the pericardium, especially the pleura."

The pericardial friction rub is also variously described. "A superficial to and fro murmur produced by movements of the heart." (Mackenzie.) "A friction rub is heard in only 21 per cent of cases." (Cabot.) Collin (*Exploration de la Poitrine*, Paris, 1824) called it the *cri de cuir* and described a case, just before effusion occurred, as *craquement* (creaking) of new leather. Stokes remarked on its resemblance to other cardiac murmurs and certainly it is difficult to make anything specific out of it. Segall (Arch. Int. Med. 51: No. 1, Jan., 1933) has given the best maneuver for the detection of the pericardial friction rub. Noticing its occasional appearance and frequent disappearance, he reasoned that the serofibrinous exudate would often have just sufficient serum to separate the two layers of the pericardium and by shaking the patient the heart might be caused to swing, bringing the two layers of the pericardium into contact. Postural changes, rolling of the body, as well as shaking, may bring out the friction rub, even if only for a brief time.

The two cardinal signs of fibrinous pericarditis, pain and friction rub, being then so evanescent, uncertain and dependent on circumstances, it is no wonder the diagnosis is missed so often.

Pericardial effusion develops usually as a terminal stage of acute fibrinous pericarditis. Tuberculosis of the pericardium appears in the form of an effusion. It is possible to make the diagnosis of pericardial effusion far more often and reliably than that of fibrinous pericarditis, which is fortunate because therapy is important in effusion, and is of little moment in simple pericarditis.

The valuable experimental and clinical studies of Williamson (Pericarditis With Effusion. An Experimental Study, Arch. Int. Med. 25: 206, Feb., 1920; A Clinical Study of Twenty-three Cases, J. A. M. A. 77: No. 26, Dec. 24, 1921), showed that the pericardium holds about 100 c.c. of fluid before it begins to be stretched. When effusion occurs in the pericardium, the heart neither sinks, as Skoda thought it did, nor floats, as Schaposhinoff thought it did, but acts as does an expansile organ which is fixed by attachments (to the great vessels) in a semi-elastic limiting membrane. It acts indeed just as we describe the lung as acting on pleural fluid (see p. 440)—i.e., by pressing the fluid out against and along the two layers of the visceral and parietal serous membranes. Williamson showed, by injecting a gelatin and agar mixture into fresh cadavers, that fluid first forms in the angle made by the anterior chest wall and the heart, between the right ventricle and the diaphragm, pushing down the latter and also the left lobe of the liver. Even when small amounts of material were injected (300 c.c.), the apex was covered by at least a thin layer of fluid.

The angle formed by the bulging pericardium and the liver was not in a single case obtuse (this contradicts Ebsten's sign which is a rounding of the cardiohepatic angle) nor was there ever any dullness in the fifth right interspace (Rotch's sign). As more fluid is forced in (up to 650 c.c.), it accumulates over the great vessels at the base, even in the erect position and the

anterior surface of the heart remained in part uncovered, so that clinically even in large accumulations a friction rub could be heard directly over the pericardium.

The local physical signs then of pericardial effusion are palpable left lobe of the liver, increase in percussion dullness of entire heart area, and friction rub over the precordium. The x-ray gives confirmatory evidence (p. 697).

Besides these local signs the examiner should look for the constitutional signs of acute and chronic compression of the heart as described by Beck (*Am. Heart J.* 14: No. 5, Nov., 1937).

The compressed heart produces a distinct clinical entity. The compressed heart is a small, quiet organ. It cannot undergo dilatation. It cannot undergo hypertrophy. It is the exact opposite of the dilated hypertrophic heart. It sends out less blood, considering the pressures exerted on the venae cavae as they penetrate the pericardial cavity. These pressures under normal conditions are negative or less than a pressure of atmosphere. If the pressure in the pericardial cavity is rapidly raised, the venae cavae and auricles are immediately collapsed unless the venous pressure is raised.

In chronic compression it is possible to attain 40 to 45 cm. of water in the pericardium. Why will a compression of 15 to 20 cm. kill when applied acutely and why will 40 to 45 be tolerated in chronic conditions? The explanation lies in the venous pressure levels. There is not enough blood in the vascular system to elevate venous pressure above 15 to 20 cm. in acute compression. In chronic compressions there is evidence that an increase in the circulating blood volume takes place. In chronic compression the liver enlarges, but not in acute compression.

The triad of symptoms of acute compression is (1) a small, quiet heart; (2) a rising venous pressure; (3) low arterial pressure. The triad of chronic compression is (1) a small, quiet heart; (2) high venous pressure; (3) ascites and enlargement of the liver. Difficulties come in recognizing the small, quiet heart.

To the constitutional signs should be added *pulsus paradoxus*, described by Kussmaul in 1874 (*Berl. klin. Wehnschr.*) thus: "Chronic inflammation of the pericardium and its obliteration, which is a criterion of mediastinitis, leads to a peculiar pulse phenomenon with unusual behavior of the neck veins. During the time that the sternum with each inspiration exerts a narrowing tug upon the ascending aorta or the arch, the pulse in all the arteries becomes smaller, while the heart movements remain constant. This paradoxical pulse is in reality a regularly recurring waxing and waning." The phenomenon does not occur exclusively in pericardial effusion. Cauchat and Katz (*Arch. Int. Med.* 33: 350, March, 1924) found it in respiratory disease, causing modification of intrapleural pressure, and in cases of mediastinopericarditis with thoracic adhesions. That it is caused by pericardial effusion pressure is shown by the disappearance of the phenomenon on tapping the sac. The unusual feature of *pulsus paradoxus* associated with pericardial effusion is its singular occurrence in patients presenting no clinical evidence of respiratory discomfort. It is a valuable sign of pericardial effusion.

Adhesive pericarditis may occur as a terminal event of any inflammation of the pericardium and as an unexplained phenomenon in so-called Pick's disease, Concato's disease, or polyserositis.

The classical signs are:

1. Cardiac hypertrophy not explainable on the basis of aortic regurgitation or arterial hypertension.
2. Periapical systolic recession (around the systolic thrust).
3. Broadbent's sign, systolic retraction of the tenth and eleventh intercostal spaces posteriorly, especially on the left side.
4. Inspiratory filling of the neck veins (Wenckebach).
5. Diastolic shock (felt and heard over the region of the heart).
6. Pulsus paradoxus.
7. Dieulaide's electrocardiographic sign—fixation of the electrical axis. (*Arch. Int. Med.* 35: 362, March, 1925.)

These signs, however, are all likely to be disappointing either by being obscure or by lack of definiteness. Many cases must be diagnosed on inference. Congestive heart failure in a child or very young adult is suggestive; congestive heart failure with ascites but no edema of the feet, or without fibrillation with a history of rheumatic heart disease, equally so.

Pick's Disease. Concato's Disease. Multiple Serositis. Mediastinopericarditic Pseudocirrhosis of the Liver.—A syndrome consisting of chronic fibrous or callous thickening of the pericardium, with chronic sclerotic mediastinitis, and thickening of the serous surface of the liver with cirrhosis, with myocardial failure from compressed heart and ascites. Concato (*Gior. internaz. d. sc. med.* 3: 1037, 1881) described the liver changes and Pick (*Ztschr. f. klin. Med.* 29: 1896) the adhesive pericarditis and liver changes. The two entities may occur separately or together or in sequence. No definite cause is known. The age incidence is among the young, around fifteen years: the oldest patient I find reported was thirty-six. Rheumatic fever has been suspected. White (*Chronic Constrictive Pericarditis—Pick's Disease, Lancet* 2: 539-559, 1935) reported 15 cases, 2 due to tuberculosis, 3 due to other infections, 10 due to unknown causes, none due to rheumatism.

Pick described three cases (including the post-mortem examination) of what he called pseudocirrhosis of the liver resulting from chronic adhesive pericarditis involving the mediastinum. The sex and age of these three patients were as follows: male of forty-seven years, male of twenty-six years, and male of twenty-four years. In the third case tuberculosis was the etiologic factor behind the pericarditis, in the second case tuberculosis was the probable factor, and in the first case the cause was unknown.

His first sentences and his conclusions are as follows:

.. "To differentiate clearly between primary and secondary disease of the liver is very difficult in occasional cases where liver enlargement with more or less ascites eventually leads to cirrhosis. This is especially the case if there are no well-marked physical signs of a heart lesion or of circulatory stasis in the upper part of the body.

"Conclusions.

"1. There is a symptom complex of *pericarditic pseudocirrhosis of the liver* which is deceptively similar to one of the mixed forms of hepatic cirrhosis with enlarged liver and considerable ascites but no jaundice. This pseudocirrhosis of the liver is caused by disturbances of the circulation of the liver due to latent pericarditis. These circulatory disturbances lead to an increase in connective tissue (fibrosis or cirrhosis) which in turn causes stasis in the portal circulation with marked ascites.

"2. This symptom is found preponderantly in young individuals, but it may be observed also in later periods of life.

"3. The following points are important in the differential diagnosis: (a) absence of an etiological factor for cirrhosis of the liver, (b) history of a previous pericarditis, and (c) earlier occurrence of edema of the legs. Certainty can come only through subsequent examination of the heart."

In polyserositis (Guyer and Smith: *Lancet* 230: 362, Feb. 15, 1936) the fluid obtained from the pleural cavities is usually clear, yellow, cell-free and sterile—and contains 3 per cent of albumin. The ascitic fluid is occasionally chylous.

Polyserositis is diagnosed on any of these symptoms: mediastinal and/or abdominal venous obstruction, recurrent effusion into the serous cavities, adherent pericardium, and enlargement of the liver.

Differential diagnosis is between mediastinal neoplasm, Hodgkin's disease, adherent pericarditis, and cirrhosis of the liver. Beck thinks such terms as adhesive pericarditis, obliterative pericarditis, Pick's disease, Concato's disease are confusing. Adhesions to the heart do not produce dilatation, hypertrophy, or failure of the heart. He recommends distinguishing only acute and chronic compression of the heart.

Suppurative pericarditis occurs in most instances as a complication of a general septic process or localized sepsis, most often pneumonia or osteomyelitis. The local signs are no different from those of any accumulation of fluid in the pericardium. (See Adams and Polderman: *Suppurative Pericarditis*, *New England J. Med.* 225: No. 2, Dec. 4, 1941.)

Pneumopericardium, or *pneumohydropericardium* occurs as the result (in order of frequency) of trauma, tuberculosis of the glands or lungs, attempted paracentesis or pneumothorax, perforation of ulcer of esophagus or stomach, foreign body in esophagus, cancer of esophagus, empyema, septicemia. Potentially infection of the pericardium with gas-producing bacilli will cause pneumopericardium, but in civil practice this does not enter the statistics. The physical signs which are characteristic are on percussion a high pitched tympanitic note over the precordium with the patient in the recumbent position: and on auscultation a loud metallic splashing sound called "bruit de moulin" by Bricheteau, and which Meigs likened to the sound of an old-fashioned churn. The x-ray picture is characteristic and spectacular. It shows the heart shadow with fluid in the pericardium and the pericardium itself represented as a thin streak separated from the heart shadow by the area of lessened density which represents the air or gas. (Shackelford: *Hydropneumopericardium*, *J. A. M. A.* 96: No. 3, Jan. 17, 1931.)

Calcification of the pericardium is implanted on an old adherent pericarditis or serositis (pleurisy). Youmans and Merrill (J. A. M. A. 82: No. 23, June 7, 1924) say most cases begin as tuberculosis while Smith and Williams (Arch. Int. Med. 50: No. 2, Aug., 1922) did not find evidence in even one case out of fifteen. The signs if any are of the adhesive pericarditis. The x-ray is usually final and positive.

Diseases of the Aorta

Coarctation of the aorta is a congenital anomaly in which a stenosis, more or less complete, occurs somewhere in the thoracic aorta. The stenosis may develop at the site of a patent ductus arteriosus or one of the other embryonic aortic arches. The result is that the descending aorta is small and the circulation is carried on by the development of many ordinarily small arteries, such as the superior and inferior epigastric, internal mammary, and intercostal arteries; or by another route through the subclavian, subscapular, superior intercostal, and subsidiary branches the circulation gets to the descending aorta. These ingenuities of Nature are fascinating to dissect out in an individual case, but of little clinical interest.

The patients may live for years. The diagnosis may be suspected by noting the marked pulsations in the supraclavicular and suprascapular regions, or by the sight of large intercostal, internal mammary, and left scapular arteries. The x-ray is confusing and not very helpful.

(References: Blumgart and Lawrence: Arch. Int. Med. 47: 816, 1931. Eppinger and Midelfort: Am. J. M. Sc. 185: No. 4, April, 1933. Grishman, Steinberg and Sussmann: X-ray of Coarctation of Aorta, Am. Heart J. 21: 365, March, 1941. Ulrich: Am. Heart J. 7: No. 5, June, 1932.)

Complete occlusion of the aorta at its bifurcation has been reported over a hundred times in the literature. Most of the cases have occurred in the presence of advanced atheroma with thrombosis. It is also precipitated by embolism, following thoracic aneurysm, or coronary thrombosis with mucous thrombi in the endocardium, or dissecting aneurysm of the thoracic aorta, or at the site of bifurcation, and it has occurred in infants following infection at the umbilicus, occasionally in the course of infectious diseases, such as diphtheria, typhoid, measles, etc. The generally described syndrome is (1) sudden pain in the legs, coldness, pallor, and cyanosis; (2) paraplegia, and (3) ascending gangrene. This seldom occurs in full flower and there is occasionally seen the remarkable picture of collateral circulation re-established as in coarctation with the patient living for years. (Gross and Phillips: Complete Occlusion of the Abdominal Aorta, Am. J. M. Sc. 200: No. 2, Aug., 1940; and Hermann, Willis, McKinley and Karotkin: Am. Heart J. 26: No. 2, Aug., 1943.)

Dissecting aneurysm of the aorta, which is found in one of 500 autopsies, is produced by a rupture of the internal coats of the artery and the penetration of blood along a false channel between the inner and outer coats. Any large arterial vessel may be so affected; the aorta and pulmonary artery most frequently. In the course of time the effused blood ruptures either externally or internally. Syphilitic aortitis is usually not a cause: in fact the inflamma-

tion of the median coat of the aorta in syphilis acts as a preventive of such an occurrence. Usually an atheromatous plaque extends into a linear tear and presents the beginning of a line of cleavage. All aortae in which this occurs have weakened media. The rent occurs most frequently in two places: (1) the ascending aorta and (2) the isthmus of the aorta. The final rupture of the misdirected stream of blood is usually into the pericardium and death then is instantaneous.

The diagnosis is naturally fraught with difficulty—so much so that it is seldom made. There is initial severe pain which is usually mistaken for angina.

The pain may radiate into the arms if the brachial vessels are obliterated, or involved in the tear. Pain is usual in the abdomen and legs. In the Massachusetts General Hospital Case Record No. 27292 (New England J. Med. 225: No. 8, July 17, 1941) the presenting symptom was pain in the leg, with absence of pulsation in the femoral artery and the limb cold and vivid. Life however, may be maintained for months—in Graybeil and Sprague's case (Am. Heart J. 21: No. 4, April, 1941) for a year. In such cases two aortae are produced. Other symptoms are dyspnea, loss of weight, great fatigue and distress, hematuria, cardiac murmurs, etc. Local symptoms, pulmonary hemorrhage, cold, blue, flaccid limbs with no evidence of limb circulation, and continuous chest pain depend on where the aneurysm dissects to. A bizarre set of findings occurs when the dissection invades various intercostal and lumbar branches interfering with the circulation of the cord—transient, temporary or permanent paralysis of muscle groups of the legs.

(References: McGeehy: J. A. M. A. 108: 1690, 1937. Glendy, Castleman and White: Am. Heart J. 13: 129, 1937. Willis and Craig: Cardiac Classics, p. 256. Hadley: Dissecting Aneurysm of the Aorta, Med. Rec. 154: No. 1, July 2, 1941.)

Atheroma of the Aorta or Arteriosclerosis of the Aorta.—While part of the generalized process all over the body atheroma is quite likely to show first in the aorta, and indeed as Aschoff says, it is a process from which no individual escapes. To quote further from Aschoff (*Lectures on Pathology*, Paul B. Hoeber, New York, 1924, pp. 131-153):

"We must differentiate (in the structure of the aorta) an ascending period, a summit, and a descending period. The first is characterized by an equal increase in all the tissue elements of the vessel wall. In the second the artery retains its form more or less. In the third there commences the progressive dilatation of the vessel which increases with age. The ascending period in the life of the vessel ends with the thirty-third year: the summit from then to the forty-fifth year: which marks the commencement of the descending period. The vessel becomes overstretched not only in the transverse, but in the longitudinal diameter as well, and so arises the characteristic widenings and tortuosities of the vessel. . . . In old age there is a marked decrease in elasticity. While the isolated aorta of a thirty-year-old adult can be stretched several centimeters it is impossible to do this with the aorta of an individual in his sixth or seventh decade."

The histologic changes which occur are progressive and occur mostly in the intima. They can be seen in the earliest stage around the openings of the

intercostal arteries as slightly elevated, flattened, yellowish streaks. Later they are found in many places in the intimal surface of the vessel. They represent a fatty or cholesterolin infiltration, and in the course of time they present the appearance of a number of hillocks, giving the inside coat of the artery a distinctly uneven surface. The media is seldom much affected, but these intimal infiltrations reduce the elasticity of the artery's wall. In the course of time they become calcified and the surface is broken giving the characteristic appearance of the ulcerated atheromatous aorta.

The process rather tends to select the arch, transverse and descending aorta in contrast with syphilis which tends to localize in the ascending aorta, but these distinctions are not rigid.

This aortic atheroma causes a quite definite and recognizable clinical syndrome. It is curious that in modern textbooks on medicine—Osler, Cecil, Musser—the condition is hardly mentioned. Meakins alone gives it consideration. Essentially the syndrome is a mild form of congestive failure, or rather a limitation of the exertion capacity of the circulation. You need no instruments of circulatory capacity to measure it—the individual reduces his golf game from eighteen to fifteen holes: then to twelve, then to nine. He no longer ever takes the stairs two at a time. He requires an hour and a quarter to walk his four miles, and prefers to do two and a half miles in one hour.

It may go further than that, and while it is, of course, true that the coronary vessels, the myocardium itself and the renal glomeruli are affected, I have seen the syndrome develop when I believe I could incriminate the aortic changes almost alone. One of the foremost clinical cardiologists of this country developed complete congestive failure, died of it, and practically nothing else but his aorta was involved. During his illness he said twice that he felt his aorta change its bed as it elongated.

The physical and x-ray signs are few and may be difficult to demonstrate. There is mild hypertrophy. There may be episodes of left ventricular failure with acute pulmonary edema. A systolic murmur developing after the age of fifty is practically pathognomonic. In a life insurance examination, for instance, where previous examination within three to five years had revealed no murmur, the discovery of a systolic murmur indicates atheroma. The murmur may be at the apex, indicating either that the mitral valves are somewhat calcified or that the murmur in the arch and descending aorta is transmitted, or it may be high up over the sternum. Loud second aortic sounds are of almost equal significance. The x-ray may show calcified plaques or a tortuous coiled aorta. (Dunn: *The Uncoiled Aorta*. I. The Normal Aorta, *Am. J. Roentgenol.* 23: No. 4, April, 1930; II. The Pathologic Aorta, *Am. J. Roentgenol.* 24: No. 2, Aug., 1930.)

Syphilis of the aorta is always due to acquired syphilis. In a series of cases of congenital heart disease studied clinically and post mortem with this particular question in mind, there was no evidence of any such association. In a study of cases of congenital syphilis (see papers by Prevatali, Nicholson and Moon-Adams: by Givan: and by McCulloch, all printed in the same number of the *Am. Heart J.* 6: No. 1, Oct., 1930. Symposium on cardiovascular

syphilis) there was no evidence of heart disease, aortic infiltration, widening of the aortic arch by x-ray, etc.

Aortitis was found in 0.85 per cent of 5,706 men over forty years of age, who were previously considered healthy (policemen and firemen), and of this group about 10 per cent had serologic signs of syphilis. (In about 50 per cent no Wassermann test was made.) In 300 autopsies Waite found syphilitic aortitis in 33 (16 of whom had aneurysm). This is a very high record of incidence. The autopsies were done at El Paso, Texas, and while no social statistics are given, the paper mentions two Mexicans. In rural America the incidence is almost negligible, and in urban America, in the better economic brackets class, the incidence can hardly be more than a fifth of 1 per cent. (Although Goodridge, in the third edition of Cecil's *Textbook of Medicine*, states that "4 to 7 per cent of all patients who come to autopsy in general hospitals show syphilitic aortitis.")

The pathologic changes in the wall of the aorta represent a progressive development, which is sometimes rapid and sometimes slow. The fundamental lesion is an obliterating endarteritis of the vasovasorum. There is a round cell infiltration around the vessels, many of which are obliterated. Following this there are changes in all the coats of the artery, but particularly in the media, with a loss of elastic fibers and replacement by fibrous tissue. In its terminal stage it is essentially a meso-arteritis.

Grossly the first changes are seen as gray, wheatlike patches on the surface of the aorta often around the mouths of the coronary arteries though there is no disposition for the process to invade these arteries to any depth. Later these patches become tougher, more extensive and intermingled with pitted scarred areas. The ascending aorta is particularly likely to be the seat selected for these changes. The loss of elasticity leads to a general dilatation of the affected aorta. If the process goes downward, it involves the aortic cusps leading to aortic regurgitation, and above the valves the weakening of the arterial wall may result in aneurysm. Whether coronary disease is a complication in the sense that it produces typical anginal attacks is a moot point. Syphilitic aortitis produces substernal pain, but it is not typically anginal. In Reid's series there was involvement of the mouths of the coronary arteries in 12 per cent, but none produced anginal attacks.

The diagnosis of syphilitic aortitis in its late stages and even its medium late stages, even when uncomplicated, has a high percentage of success. On the basis of symptoms and physical signs alone, it is not difficult, and when the services of the x-ray and specific serologic tests are enlisted, the chances of diagnosis are correspondingly improved. *Dyspnea* is the most frequent symptom (87 per cent), with paroxysmal and nocturnal forms of dyspnea especially prominent. The onset is abrupt, the attack lasts about fifteen minutes, during the interval the patient is quite comfortable; the attacks come on several times a day or night. *Cough* occurs in 40 per cent of cases. *Pain* occurs in 30 per cent of cases: it is usually substernal, at about the level of the third rib, but this is not absolute; the pain may be anywhere. It tends to be continuous for days at a time. It may be called indigestion. *Weakness* is a frequent

symptom, when brought out by questioning. When symptoms begin in a patient with aortitis, the general health breaks quite suddenly and the patient becomes tired and sick.

The physical signs are, first, the appearance of a breakdown in health, pallor, emaciation and loss of muscle tone, indisposition to activity, a frightened or discouraged countenance. The dilated arch can be made out by *percussion*, especially on the right side, with *dullness* in the second and third costal interspaces. The *second sound* has been described as particularly characteristic; it changes in both loudness and quality, being called the *tabourka* sound, likened to a distant Indian drum. In spite of the vivid descriptions of this sound it cannot always be distinguished from the second sounds in hypertension and atheroma of the aorta. But it was found in 5 per cent of 200 syphilitic patients under fifty years of age, and only once in 500 normal controls of the same age, so that if hypertension and atheroma can be ruled out it is a valuable sign.

But from a clinical standpoint the hope of therapy lies in very early diagnosis, and here the prospects are not so good, on the basis either of symptoms, signs, x-ray or serologic evidence. Boharas, Hollander and Goldsmith (*Am. J. M. Sc.* 203: No. 1, Jan., 1942) are completely pessimistic, saying, "It is impossible at present to make a positive clinical diagnosis of early syphilitic aortitis." Danzer (*Ann. Int. Med.* 5: No. 1, July, 1931) thinks that a diagnostic triad of early syphilitic aortitis is angina pectoris, a negative carotid sinus reflex, and a rapid blood sedimentation rate. (The carotid sinus reflex is elicited by pressing the thumb over the carotid artery at the level of the thyroid cartilage. At this point the vessel bifurcates into its internal and external branches and a slight bulging of the artery called the carotid sinus may be felt. The heart rate is counted for 10 seconds, then the sinus is compressed for ten seconds, and the cardiac frequency is again determined. Similar counts are made for the following two 10-second periods. The reflex is positive if there is a distinct slowing during the carotid compression. The explanation of the negative reaction in syphilitic aortitis, as given by Danzer, is that syphilitic aortitis is generally unassociated with coronary closure or lesions at the carotid sinus unless complicated by atherosclerosis. Since such lesions are required to give a positive reaction, its absence in aortic syphilis may be understood.) The application of this triad has not inspired confidence in the diagnosis of early syphilitic aortitis in my hands.

Aneurysm of the Aorta.—Boyd (*Am. J. M. Sc.* 168: No. 5, Nov., 1924) collected the following statistical data in 4,000 reported cases of aneurysm of the thoracic aorta:

Sex—Female—	606.	Male—	3,403.
Age—Females greatest incidence	46	50.	
	Males—	36-45.	
Etiology—Syphilis proved	92	per cent.	
Location of lesion:			
Ascending aorta	1,675.		
Arch	1,106		
Descending	506.		
Thoracic	156.		
(lower descending aorta)			

SYMPTOMS.—Pain first complaint, 29 per cent. Dyspnea first complaint, 31 per cent. Cough first complaint 19 per cent. Loss of weight chief complaint 1.9 per cent. Tumor, dysphonia, dysphagia, palpitation, fever, pulsation, ocular phenomena, recurrent laryngeal nerve involvement all of lesser percentage.

INCORRECT DIAGNOSIS.—130 cases.—Rheumatism 32; tuberculosis 22; arthritis 22; chronic bronchitis 14; failing heart 10; mediastinal neoplasm 10; endocarditis 4; angina pectoris 4.

RUPTURE.—52 per cent die of rupture. Into pericardium 31 per cent; left pleura 14 per cent; esophagus 9.4 per cent; right pleura 7.4 per cent; bronchus 7.1 per cent; trachea 6.2 per cent; externally 5.1 per cent.

Since the advent of the x-ray which can make the diagnosis of aneurysm so early and so often, and since the great decline in the incidence of late visceral syphilis (a decline almost entirely due to the efficiency of the treatment of syphilis by men in private practice, with which public health had nothing to do) one of the great pleasures of clinical life has been taken away from us—the keen satisfaction of making the diagnosis of aneurysm on physical examination alone.

The basis of this intellectual pleasure is the many structures an aneurysm may come in contact with, and the versatile nature of the pressure symptoms resulting.

Broadbent made the useful classification of aneurysms of signs and those of symptoms. In the ascending aorta the signs predominate; in the arch and descending aorta the symptoms.

Little need be added to the list of symptoms given in Boyd's table. The *cough* is brassy, loud and ringing, due to pressure on the trachea; sometimes it is like the gobble of a goose and is called "goose cough." Among the respiratory symptoms a prominent one is *asthma* which may be due to compression of the trachea or of a bronchus in which cases the signs of asthma are unilateral. *Dysphagia* is a very striking symptom, present prominently in 14 of Sanford's 71 cases (Ann. Int. Med. 4: No. 11, May, 1931).

PHYSICAL SIGNS.—Inspection is the great art in the physical diagnosis of suspected aneurysm. The examiner will look *across* the chest, against the light, with his eyes on a level with the chest wall. With the patient in every position, the examiner looks for general or local pulsations along the sternum, ribs, clavicular spaces, and along the back. *Pressure edema* of the face, or one arm, or both arms, or the chest should be looked for.

Inequality of the pupils may be due to pressure on the sympathetics, or low blood pressure in one carotid will dilate the pupil on that side. Sometimes it may represent a syphilitic iritis. Flushing of the face and ear on one side, increased temperature and unilateral sweating may occur. Abnormal pupils occurred in 13 of Sanford's 71 cases.

If hoarseness is present, an inspection of the larynx for *unilateral left vocal cord paralysis* should be made. It occurs in aneurysms of the arch which stretch or compress the recurrent laryngeal nerve.

The apex beat of the heart is seldom much displaced.

Palpation confirms inspection as to the expansile heaving tumor. A thrill is but rarely felt, but there may be a diastolic shock. The pulses were unequal in 9 out of Sanford's 71 cases. The inequality may consist of simple delay, difference in strength, or absence on one side. Naturally aneurysms involving the mouth of the common carotid or of the innominate artery produce this phenomenon. Inequality in blood pressure is even more suggestive. Blood pressure in general is little disturbed in aneurysm.

The tracheal tug of Oliver was described (Lancet, 1878) thus: "Place the patient in the erect position, and direct him to close his mouth, elevate his chin to the greatest extent, then grasp the cricoid cartilage between finger and thumb and use gentle upward pressure on it, when if dilatation or aneurysm exist, the pulsation of the aorta will be distinctly felt." The sign was noted in 12 of Sanford's 71 cases, and he considers it of not much help in diagnosis. To obtain results, however, the technique must be faithfully carried out.

Percussion shows dullness or relative dullness over the ascending or thoracic aorta, depending upon the extent to which the aneurysmal tumor comes to the surface. It is, therefore, not dependable if negative. Aneurysms of large size may be puzzlingly silent.

Percussion of the lungs, however, may make out dullness of atelectasis when one primary bronchus is obliterated.

Auscultation may bring out murmurs of any kind, mostly systolic and the ringing second aortic sound as described under syphilitic aortitis, or it may be entirely negative. Auscultation of the lungs may be more suggestive than auscultation of the heart and vessels, if compression of a bronchus has resulted in asthma or atelectasis.

Rupture of an aneurysm of the aorta into the superior vena cava gives quite a definite and pathognomonic syndrome, consisting of sudden edema and cyanosis of the face, neck, and arms. In the cases I have seen the cyanosis stopped abruptly at the rib borders. Mayers (Rupture of an Aortic Aneurysm into the Superior Vena Cava, J. A. M. A. 63: No. 3, July 19, 1924) has aptly likened the shadow of the cyanosis to a short cape over the shoulders: in his case it stopped at the third rib. There is a turgescence of veins emptying into the vena cava if these can be seen through the edema. Moist râles are heard all over the lung area, and a continuous murmur over the upper part of the chest. Shock is usually pronounced so that the rapidity of the pulse precludes timing the murmur. Death usually occurs within forty-eight hours after onset, though Anderson's patient lived five days (J. A. M. A. 81: No. 22, Dec. 19, 1923), and Weil and Earle's patient (J. A. M. A. 76: No. 25, June 18, 1921) lived five weeks. The largest series of cases reported was by Pepper and Griffith (Tr. A. Am. Physicians 5: 45, 1890) who analyzed 43 cases, but the condition cannot be so very rare: on my service at the Kansas City General Hospital I saw four cases in ten years (two in one month), and in the old von Neusser clinic in Vienna it was regarded almost as a commonplace, Professor von Neusser delighting to exhibit an example from time to time. He mentions it in his little book *Dyspnoea and Cyanosis*.

Rupture of aortic aneurysm into the pulmonary artery occurs usually in a sacculated aneurysm involving one of the sinuses of Valsalva. The symptoms are sudden, abrupt onset, with pain, cough, and soon edema of the lower extremities. There is a superficial and peculiarly intense systolic thrill accompanied by a harsh blowing systolic murmur over the second and third intercostal spaces. The aneurysm is usually so small as to show no shadow on the x-ray. About sixty cases are on record. (See Scott: J. A. M. A. 82: No. 17, May 3, 1924; White, Chamberlain and Kelson: Ann. Int. Med. 15: No. 3, Sept., 1941, full bibliography with this article.) Death is likely to follow shortly after onset, but White's patient lived twenty-one months.

Rupture of an aortic aneurysm into the right ventricle, not resulting in immediate death, has been reported a few times. It is not so much a rupture as an extension or dissection of an aneurysm behind the right posterior cusp of the aortic valve into the ventricle. The symptoms are not sufficiently definite to be called a syndrome, but an increase in substernal pain over that previously noted, with accelerated dyspnea, amounting to orthopnea in a brief space, with signs of cor pulmonale, are suggestive. (See Harris and Schattenberg: Ann. Int. Med. 20: No. 6, June, 1944.)

Aneurysm of the abdominal aorta occurs most often just below the diaphragm. It presents backward about as often as forward. When presenting backward it produces a tumor which may erode the vertebrae, causing nerve pressure symptoms of numbness and tingling in the legs, finally paraplegia. When it presents in front there is pulsation, thrill, murmur, and a palpable tumor. Epigastric pulsation of a forceful nature is so common in thin or neurotic persons that Osler's emphatic warning should be remembered by the clinician:

"No pulsation, however forceful, no thrill, however intense, no murmur, however loud, justifies the diagnosis of abdominal aneurysm unless there is a definite tumor which can be grasped and which has an expansile pulsation."

Aneurysm of other arteries than the aorta include (roughly in order of frequency) the *innominate* artery, the *popliteal* artery, the *carotid* artery, the *subclavian* artery, the *splenic* artery, and the *axillary* artery. These (with the exception of the splenic artery which is never diagnosed ante-mortem) can be recognized by the local expansile pulsation. The common iliac, posterior tibial, cerebral, temporal, ophthalmic subscapular, and brachial are less commonly involved.

Syphilis and aneurysm of the pulmonary artery are very rare. Peck (Peck, S. M.: Arch. Path. & Lab. Med. 4: 365, Sept., 1927) collected twelve cases.

Arteriovenous aneurysm is usually the result of trauma, most often a bullet wound, which produces a fistula between an artery and a vein. The commonest site of occurrence is between the femoral vessels below Poupart's ligament. Second in frequency is arteriovenous aneurysm of the vessels of the neck. The diagnosis is made on the basis of the history and physical signs—(1) edema and enlargement of the veins as the blood under arterial pressure flows into them; the leg may become longer, and hair growth may

increase; (2) thrill at the site of the aneurysm and along the course of the vessels involved; (3) *loud continuous murmur with systolic accentuation*.

Mycotic aneurysm is the name given to those which are due to bacterial infection (not syphilitic). An infected embolus with or without endocarditis is the usual form. The extravascular origin of an infected lymph node lying over an artery is rare. Mycotic aneurysms affect the aorta, the intracranial arteries, the pulmonary, the mesenteric, the tibial, or any peripheral artery. In the peripheral arteries the symptoms and signs are pain, redness, local swelling, and expansile pulsation. They may be mistaken for phlebitis. Mesenteric involvement may be suspected when symptoms of mesenteric thrombosis occurs in the course of a subacute bacterial endocarditis. In the aorta or pulmonary artery the diagnosis can never be made positively. (See Richey and MacLachlan: *Arch. Int. Med.* 29: No. 1, Jan., 1922; and Reifenshtein: *Gonococcal and Pneumococcal Aneurysms*, *Am. J. M. Sc.* 168: No. 3, Sept., 1924.)

Chapter 9

EXAMINATION OF THE CHEST—THE RESPIRATORY SYSTEM

1. Peculiarities, anatomic and pathologic, as they affect the incidence of diseases and physical diagnosis of the respiratory system.
2. Routine plan for physical examination of the respiratory system.
3. Scheme for interpretation of *physical signs* of respiratory disease by local areas.
4. Relative frequency of respiratory diseases.
5. Diseases of the respiratory system:
 - A. General.
 - B. Diseases of the bronchi.
 - C. Diseases of the lungs.
 - D. Diseases of the mediastinum.
 - E. Diseases of the diaphragm.
 - F. Diseases of the pleura.

DISEASES OF THE RESPIRATORY SYSTEM

I. PECULIARITIES, ANATOMIC AND PATHOLOGIC, AS THEY AFFECT THE PHYSICAL EXAMINATION OF THE RESPIRATORY SYSTEM

The respiratory system consists of the nose, pharynx, larynx, trachea, bronchi, lungs, pleura, mediastinum, and diaphragm. The diagnosis of the diseases of the nose, pharynx, and larynx are taken up in another section of this book.

The diseases to which these structures are liable are, naturally, by the nature of their position and constant contact with the respiration of the air, infections; also to such affections as are induced by dust in the atmosphere, foreign bodies which may be inspired, plant pollens, animal dander, etc., which cause allergy; by the nature of the pulmonary circulation the lungs are particularly liable to embolism, including septic and neoplastic embolism and hence secondary growth of lung abscesses and neoplasms. The condition of the circulation also affects the lungs when congestive failure supervenes, because chronic passive congestion and hydrothorax are evidences of this.

II. ROUTINE PHYSICAL EXAMINATION OF THE RESPIRATORY SYSTEM

1. **Temperature.**—First and most important of all, the entire respiratory system is extremely liable to bring on fever when disturbed, as opposed to the sluggishness of the gall bladder, the kidney, and the muscles in this respect.

2. **Inspection.**—It is not easy to classify a patient as being “respiratory” by general inspection as it is to suspect him of being “cardiac,” “cancerous,” “cachectic,” or “anemic.” The hyperpnea of pneumonia and the expiratory difficulty of asthma are exceptions. The catch of pleurisy is another. The difficult breathing of emphysema and pneumoconiosis is observable across a ward when the conditions are advanced but not in the early stages. But tuberculosis, neoplasm, and circulatory changes do not reveal themselves positively until emaciation and cachexia make their advent.

Local inspection should be directed toward:

1. Respiratory rate.
2. Nature of respiratory difficulty, if any, i.e., inspiratory or expiratory.
3. Asynchrony of movement of the two sides of the chest.
4. Permanent retraction and asymmetry of one side of the chest.
5. Intercostal bulging.
6. Determination of muscular atrophy.
7. Clubbing of fingers.

The respiratory rate is the only one of these which is of any significance in my experience. Physical diagnosticians like to dwell on asynchrony, intercostal bulging, Litten's sign, etc., but they contribute little of real value to any diagnosis.

By standing above a patient and looking down over the naked chest, small local changes in the muscles can be seen. These are said to be sites of underlying lung disease. Dr. F. M. Pottenger developed in himself an uncanny skill in the detection of lung disease by developing this idea. It was a delight to watch him do it, but no one was ever able to approach him in accuracy of conclusions from this method.

3. **Palpation.**—At the apices in front, over the pectorales, in the axillae, over the apices behind, down the back of the thorax.

Vocal Fremitus.—When the hand is placed on the chest over a lung area and the patient is asked to say—“one, two, three,” or “ninety-nine,” the vibrations of the vocal cords are transmitted to the examining finger. This is called *vocal fremitus*, or *tactile fremitus*. It is increased in consolidation—pneumonia, tuberculosis—and decreased or absent when there is fluid in the pleural cavity, pneumothorax, atelectasis, or large lung abscess.

It is normally increased over the apices and the right side. The further the hand is from the larynx, the greater the diminution of vibration.

A very delicate method of eliciting it is to use an Erlenmeyer flask and put the mouth on the chest and the hand over the bottom of the flask.

Vocal fremitus is one of the most valuable of physical signs in diseases of the lungs and should never be omitted from the routine examination. A sign is valuable not only for its reliability but also for the ease with which it can be recognized. Vocal fremitus is both reliable and readily learned. A student will plug away at percussion for years and make no progress, but anyone can detect differences in fremitus the first time it is tried.

4. Percussion.—Same areas as for palpation.

In health vesicular resonance will be elicited over the entire chest from a point a fingerbreadth above the inner end of the clavicle (the apices of the lung) down the right side to about the fourth rib or interspace, when the dullness due to the underlying liver begins: complete flatness where the lung border ends occurs at about the sixth rib in the midclavicular line, at about the eighth to ninth rib in the midaxilla, and the ninth to tenth rib in the scapular line in the back. The border of resonance, in other words, runs from the sixth rib in front downward toward the back and as the ribs run obliquely in an opposite direction it meets lower and lower ribs as it moves toward the spine.

On the left side the note is topographically the same except for the interposition of the heart dullness. Relative heart dullness begins at the third rib, covers the sternum from there down and infringes slightly to the right sternal border. Absolute heart dullness is represented by an irregular tongue-shaped strip from about the fourth rib down, merging into absolute liver dullness.

From the sixth rib down on the left side tympany is the normal note (Traube's semilunar space).

In the axilla, or back of the left side from the eighth to the eleventh rib, is sometimes encountered splenic dullness, but it is relative and not always present.

The physiologic dullness of the right apex is mentioned by most textbook writers since Gerhard (1836) who warned that a slightly more resonant note on the left side "does not indicate induration of the right lung." But graphic methods of sound recording have shown that this difference is not actual and for all practical purposes we can regard the two supra- and infraclavicular spaces as equally resonant. (Buck: *Physiologic Dullness of the Right Apex*, New England J. Med. 219: No. 16, Oct. 20, 1938.)

Many signs repeatedly described in textbooks are worthless either because they are too difficult to elicit accurately or tell nothing anyway. Percussion signs of this character are, in my opinion, skodaic resonance, Krönig's isthmus, Grocco's triangle, Wintrich's, Biermer's, and Friedreich's change of note, cracked pot sound.

Myotonic Irritability.—In many thin persons, a forcible single percussion stroke over the pectoralis muscle will cause a muscular wheal to rise. It remains often several minutes. Sometimes a peristaltic wave moves from this point across the muscle to its insertion. The phenomenon is particularly liable to occur in tuberculosis patients, but is not exclusive to them. What it may mean other than general weakness or a rough suggestion of tuberculosis, I do not know.

5. Auscultation.—

"In auscultating the chest be sure that the patient is comfortable, and that his muscles are relaxed. Tense muscles are apt to cause muscle sounds. Have him breathe in and out with his mouth open, slightly more deeply than usual, with a moderately quick intake and output, in a sort of gasping way, but with no increase in the respiratory rate, and always with the same intensity. The

rate should be slow enough for you to be able to shift your stethoscope comfortably and unhurriedly in time to catch the next breath. Although the inspiration must be slightly forced, the expiration must not be. In expiration the chest is simply allowed to collapse passively without any muscular effort whatever. Furthermore, expiration must follow inspiration immediately. Some patients have an annoying habit of holding the breath for a perceptible interval after inspiration. This is not only distracting, but makes it difficult to estimate the expiratory sound correctly. Be sure that no extraneous sound is produced in the mouth or throat by air vibrating against tense or too closely held lips, against the teeth, the tongue, or the soft palate. Have the patient clear his throat and do all his swallowing before you start. It is very annoying to have the patient swallow saliva during auscultation. Very often it makes a sound like râles. Some patients, either through stupidity or through innate contrariness, never can learn to breathe the way you want. Sometimes they have stiff, muscle-bound chests. Very often they are trying too hard to help you. They feel that they have to do something, and hold their bodies too stiffly erect, breathe too harshly, shrug their shoulders, or make noises in their mouths and throats. They cannot grasp the fact that you want nothing but passivity, and they will always try to improve on it. You simply will have to make the best of it." (Kraetzer: *Procedure in Examination of the Lungs*. Oxford University Press, 1930.)

The examiner will wish to control the patient's breathing; i.e., make him breathe in or breathe out, or respire rhythmically. To do this by spoken command spoils auscultation. To avoid the confusion made by sounds of the voice, the method of Bethea is useful: "I place the chest piece of the stethoscope" on the chest and "ask the patient to let me direct his breathing by the movements of my free hand. The rate of movement, and the depth by the extent to which the hand is raised and lowered." (J. Am. Therapeutic Soc., 1932.)

I. **Breath Sounds**—at the same areas as for palpation and percussion listen for:

The sounds heard over the normal healthy respiratory organs are vesicular breathing heard over lung tissue (e.g., the right chest from clavicle to sixth rib) and tracheal or bronchial breathing, heard over the suprasternal notch.

Vesicular breathing is the result of the inspired air passing over the vocal cords, modified by its passage down the trachea, bronchi, bronchioles, and into the alveoli. It is a soft sighing, with the inspiration much longer than the expiration. It should be listened for in a quiet room with only one stethoscope on the patient's chest.

"One hears during inspiration and expiration, a soft murmur, but extremely distinct, which indicates the penetration of the air into the pulmonary tissue and its expulsion." (Laennec.)

"As stated by Skoda, the average pitch of the vesicular inspiration may be represented by the consonant *v* or *b*, whispered. The pitch of the expiratory sound, according to Skoda, is a sound falling between the whispered consonants *f* and *h*." (Flint: *Physical Exploration of the Chest*, 1866.)

Bronchial breathing is louder, and higher pitched than vesicular breathing, and expiration is as long and loud as inspiration.

Between pure vesicular and pure bronchial breathing every shade of bronchovesicular breathing can be heard; on the normal chest, however, bronchovesicular breathing is heard only at the apex of the right lung, above the clavicle and at lung borders where the bronchi and thin layers of lung are superimposed; e.g., between the border of the sternum and the nipple in some spots.

II. Voice Sounds.—

Vocal resonance is auscultation of the spoken voice. Auscultation of the *whispered voice* is much more valuable in detecting areas of consolidation. Over normal lung tissue, the spoken voice in a person with a clear voice is resonant and singing. The whispered voice is heard over healthy lung except perhaps over the right apex.

III. Sounds heard in disease over the respiratory organs.—

1. **BREATH SOUNDS.**—If the lung alveoli are filled with exudate as in pneumonia, or destroyed as in tuberculosis, the vesicular note is lost and only the sound made in the bronchi or trachea, bronchial breathing, is heard. As different degrees of infiltration occur, different degrees of broncho-vesicular respiration are recognized.

"Elevation in pitch pertaining to inspiration is the character most readily recognized." (Flint, 1866.)

If fluid in the pleural cavity or thickening of the pleura occurs, all breath sounds will be absent or diminished.

Amphoric breathing is a loud metallic breathing heard over a cavity with rigid walls. It has been compared to the note heard when blowing over the mouth of an empty bottle (amphora).

Cogwheel breathing is interrupted inspiration occurring in early tuberculosis and over the lung when pleural adhesions are present. Sometimes it indicates merely nervousness or trembling.

2. VOICE SOUNDS.—

Bronchophony (or pectoriloquy) of the spoken voice is the distinct transmission of audible words, not just sounds, and occurs over dense pulmonary consolidations.

"Egophony resembles pectoriloquy in that it also consists of loud resonance of the voice: it is quavering and jerky like the bleating of a goat." (Laennec.) This peculiar kind of spoken voice through the stethoscope is heard at the edge of moderate-sized pleural effusions at the lower angle of the scapula.

Examination of the whispered voice is a much more delicate diagnostic procedure than examination of the spoken voice. Naturally it is absent over pleural thickening and fluid. It is increased by the smallest amounts of lung infiltration. Normally heard distinctly nowhere except over the trachea and primary bronchi, in infiltration it may be heard even in the bases over the scapulae.

"When tuberculosis cavities exist, a cavernous voice sometimes has a musical tone resembling the sound produced by speaking into an empty vase. It is then called amphoric." (Flint, 1866.)

3. ADVENTITIOUS SOUNDS.—

A. *Râles* are adventitious sounds not heard in health.

(1) *Moist râles* (due to fluid in the respiratory tree):

Crepitant: Fine sharp sounds at the height of inspiration and caused by moisture or exudate in the alveoli. They are heard mostly in pneumonia. They can be imitated by the sound of salt thrown on the fire, or moistening the thumb and forefinger with saliva and separating them just outside the ear.

A variety of crepitant râles was named "consonating" by Skoda. They are transmitted to the ear through con-

solidated lung tissue and have a ringing bronchial quality. They are not as well heard through the rubber tubes of the binaural stethoscope as through the wooden monaural type.

Read Laennec's description of the physical signs of pneumonia (1826): "The crepitous rattle is the pathognomonic sign of the first stage—it conveys the motion of very small equal-sized bubbles. The sound of respiration is still heard distinctly.

"When the inflammation has reached the degree of hepatization, we no longer perceive the crepitous rattle or the respiratory sound. Bronchophonism exists—bronchial respiration and cough always accompany bronchophonism. These physical signs of hepatization are always accompanied by a dull sound on percussion.

"When resolution takes place before hepatization has supervened, the crepitous rattle becomes daily less perceptible while the natural sound of respiration becomes gradually more distinct and at last alone is heard. When hepatization has taken place, the resolution is invariably announced by the return of crepitous rattle (*rhonchus crepitans redux*). To the crepitous rattle is gradually joined the natural sound of respiration which daily becomes more distinct and at last exists alone."

Subcrepitant are coarser and not so loud as crepitant râles, heard most characteristically in the early infiltration of the alveoli in tuberculosis.

Mucous—produced by moisture in larger tubes as in cavities and in bronchi.

Bubbling—the coarse râles produced by pulmonary edema in the trachea—the death rattle.

(2) Dry râles—(due to narrowing of the bronchi):

- (a) *Sibilant and sonorous*—hissing, creaking and snoring sounds, expiratory in time, produced in the finer or larger bronchi in asthma and in acute bronchitis; sometimes in emphysema.

The diagnosis of râles, unlike heart murmurs, depends almost entirely on recognition of their character. A crepitant râle once heard can never be forgotten. There has been much discussion as to the impossibility of classifying râles, but I see no objection to the old standard description given above.

Accentuation of râles by cough is a most important diagnostic procedure. Ask the patient to breathe out, cough, and breathe in. The cough is a forced expiration which forces the too moistened alveolar surfaces together: the following inspiration opens them up, producing the râles.

"Lawrason Brown said the specialist could be distinguished from the general practitioner by the fact that when he examined the lungs he made the patient cough." (Waring. *Op. cit.* 1936.)

- (b) *Succussion splash*—a splash heard on shaking the patient, due to fluid and air together in the pleural cavity.

- (c) Metallic tinkling is heard over cavities with rigid walls, containing fluid. Laennec compared it to the sound of a "drop of water which one lets fall into a earafe three-quarters empty." (For another explanation see Barach: Arch. Diag., Jan., 1910.)

"Other illustrations are tinkling of a small bell; shaking a pin in a decanter; the ebullition of fluid in a glass retort or flask." (Flint, 1866.)

- (d) Pleural friction rub is produced when the two surfaces of the pleura are inflamed. Hippocrates said the lung "squeaks like a leather strap." It is heard during both inspiration and expiration.

III. SCHEMA FOR INTERPRETATION OF LOCALIZED PHYSICAL SIGNS IN DISEASES OF THE RESPIRATORY SYSTEM*

I. Inspection:

1. *Lessened expansion of one side of the chest.* Beginning lobar pneumonia. Acute fibrinous pleuritis. Obstruction of main branches from foreign body, aneurysm, or carcinoma. Atelectasis of one or more lobes of the lung. Hydrothorax. Pleurisy with effusion. Pneumothorax. Empyema. Pulmonary embolism and infarct. Retraction and fixation of one side. Chronic pleural thickening. Empyema. Actinomyces.
2. *Localized muscular atrophy*—means a chronic process usually tuberculosis. Lung abscess. Localized empyema.

II. Percussion:

1. *Generalized loss of resonance.* Old chronic inflammation of any kind. tuberculosis, even localized, will eventually produce a fairly generalized collapse of the lung. Bronchiectasis.
2. *Localized loss of resonance, dullness to flatness.* Tuberculosis. Lobar pneumonia. Empyema. Lung abscess. Atelectasis from bronchial obstruction. Metastasis. Pulmonary embolism. Pleural tumor, endothelioma. (These may be localized anywhere.) Pleural effusion. Hydrothorax (nearly invariably localized at base, usually behind).

III. Palpation:

1. *Vocal fremitus and whispered voice increased:*

At one apex or both—tuberculosis or early pneumonia.

Over one upper half side of chest, with sudden onset of pain, increased respiratory rate and fever—pneumonia.

Over one upper half side of chest—without pain or dyspnea, with fever, with or without cough and expectoration—tuberculosis.

Over base one side, with pain, dyspnea, fever—pneumonia.

Over base one side, without pain, dyspnea, fever—fibroid phthisis, chronic passive congestion, infarct, fibrosis, carcinoma.

2. *Vocal fremitus and whispered voice diminished:*

At one apex—old tuberculosis with pleural thickening or atelectasis from foreign body or bronchiogenic carcinoma.

Over entire one side of chest—hydrothorax, pleural effusion, empyema, pneumothorax, atelectasis from compression of main bronchus from aneurysm, or Hodgkin's disease.

*With acknowledgments to Kraetzer: *Procedure in Examination of the Lungs*, Oxford Press, 1930.

One side of chest localized area front, back, or axilla base of apex—lung abscess, neoplasm.

One side of chest, base, back, front increases v.e.—pleural effusion, empyema, hydrothorax.

IV. Auscultation.

1. Diminished breath sounds.

A. Diminished intensity over a considerable part of one side of the chest.

(1) *The area of diminished breath sounds is resonant.*

(a) The patient is not in pain and is not dyspneic. Apical tuberculosis. Artificial pneumothorax. Cavity. Hemiplegia. Pulmonary embolism. Metastasis.

(b) The patient is in pain and is not dyspneic. Intercostal fibrositis. Fibrinous pleurisy.

(c) The patient is dyspneic and may or may not be in pain.
i. Displacement of mediastinum away from side of lesion. Pneumothorax.
ii. No displacement of mediastinum—lobar pneumonia, too early to produce râles.

(2) *The area of diminished breath sounds is dull.*

(a) The area involved is at the base.

i. Displacement of mediastinum away from side of lesion. Effusion. Empyema. Hydro-pneumothorax.

ii. Displacement of mediastinum toward side of lesion. Adhesive pleurisy. Cavity. Abscess. Bronchiectasis. Massive collapse.

iii. No displacement of mediastinum. Effusion. Fibrosis. Neoplasm.

(b) The area involved is at the top of the chest.

Tuberculosis. Upper lobe pneumonia. Neoplasm.

B. Diminished breath sounds over a small area. (Apex Base, Intermediate area).

Tuberculosis. Encapsulated fluid. Thick pleura. Abscess.

2. Harsh breathing.—Prolonged expiration. Bronchovesicular breathing.

A. The area is resonant or partially resonant. A pulmonary lesion which is not superficial, deep enough to have an area of localized emphysema around it, between it and the chest wall. Pulmonary tuberculosis. Bronchiectasis. Lung abscess. Bronchopneumonia. Asthma.

B. The area is dull. Lobar pneumonia. Pulmonary tuberculosis. Bronchopneumonia. Virus pneumonia.

3. Whispered voice.—Same significance as vocal fremitus.

4. Râles.

In judging râles consider all the data that have gone before—symptoms, position of trachea, vocal fremitus, percussion note, type of breathing, whispered voice.

Second, determine the type of râle dry or moist (fine, medium, or large).

Third, geographic distribution:

Râles at the base

Unilateral—against tuberculosis.

May be lung abscess or unilateral bronchiectasis, perhaps from foreign body.

Bilateral—if at margins, and disappear on deep breathing, simply the marginal atelectasis of the overfed, sedentary middle-

aged; if more numerous and do not disappear on deep breathing, probably pulmonary edema of chronic passive congestion

Sonorous and sibilant râles at both bases—bronchitis or asthma. In the presence of cough with blood-streaked sputum—bronchopneumonia.

Persistent bilateral basal râles—bronchiectasis.

Unilateral basal râles with pain, rapid respirations—lobar pneumonia.

Unilateral basal râles with trachea pulled to affected side and clubbing of fingers—lung abscess.

Unilateral basal râles with hemoptysis—pulmonary infarct.

Râles at the apex

Transient, clearing up on cough—bronchitis, medium-sized tubes.

Persistent—tuberculosis.

Generalized râles

Bronchitis or asthma. Advanced tuberculosis, miliary tuberculosis.

Râles over the hilum

Bronchitis.

Râles of lobar distribution

Lobar pneumonia, tuberculosis or beginning abscess from foreign body.

Râles over intermediate or unclassifiable areas

May be anything.

IV. INCIDENCE OF RESPIRATORY DISEASE

(5,000 consecutive cases of respiratory disease as collected from the records of the Kansas City General Hospital and of the University of Kansas Hospitals—1930-1942.)**

		PER CENT
1. INFECTIONS:		
Pneumonia		32.0
Lobar	12.0	
Lobular	14.0	
Undetermined	6.0	
Tuberculosis		31.0
Actinomycosis		•
Bronchiectasis		6.0
Spirochetal infection—Vincent's	3.0	
Other infections—(molds)		•
Lung abscess		2.0
Following pneumonia	2.0	
(including gangrene)		
Bronchiectatic	1.4	
Vincent's infection		
Foreign body	0.4	
Embolic	•	
Pleural infection		4.0
Acute fibrinoplastic pleurisy	1.0	
Pleural effusion	2.0	
Empyema of the pleura	1.0	

**Acute bronchitis, coryza, etc., excluded by the circumstance that this is hospital material. They would, of course, be so numerous as to vitiate the figures for practical purposes.

2. ASTHMA		9.0
Allergic	8.5	
Infectious	0.5	
3. EMPHYSEMA		8.0
4. PNEUMONOCOCCUS, etc.		2.0
5. FOREIGN BODY IN TRACHEA		*
6. CIRCULATORY CHANGES, CHRONIC PASSIVE CONGESTION, PULMONARY EDEMA, INFARCT, EMBOLISM, HYDROTHORAX		2.0
(Only those in which respiratory disease was considered as dominating the picture—such as when at first pneumonia or tuberculosis was suspected. Terminal pulmonary edema not included.)		
7. NEOPLASTIC DISEASES:		
Secondary		0.5
(Only those in which respiratory diseases dominated the picture.)		
Primary		0.5
Bronchiogenic carcinoma	0.4	
Primary lung carcinoma	*	
Endothelioma pleura	*	
Hodgkin's, etc., mediastinum		2.0
Cystic disease of the lung	*	
8. DIAPHRAGMATIC HERNIA		*
9. PNEUMOTHORAX (SPONTANEOUS)		*

*Too few to make calculation valuable.

V. DISEASES OF THE RESPIRATORY SYSTEM

A. General

1. **The Common Cold.**—Coryza, or the common cold, is an inflammation of the nasal mucosa, the pharynx, the larynx, the tracheal mucosa, and the bronchi—either, any one, or all. It is probably caused by a virus. It presents no physical signs other than fever, redness of the pharynx, sputum in its later stages, and possibly the signs of bronchitis. The only function the diagnostician has is of exclusion—to be sure what the patient says is a cold is not pneumonia, tonsillitis, diphtheria, pleural effusion, acute rheumatic fever, etc.

2. **Influenza.**—I do not know what influenza is. I know what they say it is, but that is not the same thing. It is defined as a generalized infection of the respiratory mucous membranes, something like the common cold but more prostrating and invading the alveoli of the lung as well as the bronchioles. During the epidemic of 1917-1919 I saw many thousands of cases of a disease that we called influenza. It was undoubtedly a specific disease entity. There was a generalized respiratory infection. It came on with great abruptness. It developed lobular pneumonia in about 33 per cent of cases. These cases were nearly invariably fatal, and were especially characterized by a slate-colored cyanosis. It was extremely contagious. Since then during various winters there have been epidemics of what is called influenza. The disease and the patients no more resemble the patients we saw in 1917-1918 than a hangnail resembles generalized carcinoma. No one will ever convince me

they were the same disease. All I can say in a treatise on diagnosis is that if another epidemic of that disease we had in 1917-1919 comes along, you will know it right away.

B. Diseases of the Bronchi

Acute bronchitis as a separate entity is hardly to be distinguished from the common cold. The only physical signs are sonorous and sibilant râles, and these occur only late in severe cases.

Recurrent acute bronchitis is usually, in my experience, due to chronic nasal infection. The common cold leaves an immunity. People who keep getting recurring colds all through the season are usually those who have a more or less silent sinus disease which keeps infecting the bronchial tree.

Acute laryngotracheobronchitis of an especial form, with serious swelling of the mucosa and submucosa and the formation of a tough, resinous, diphtheria-like exudate with the production of dangerous dyspnea, has been several times described. (See Holinger, Paul: *Dis. of Eye, Ear, Nose and Throat*, 1941, 1: 58-62; Le Jeune and Bayon: *J. A. M. A.* 117: 1316, Oct. 18, 1941; Gettings: *Ann. Otol., Rhin., and Laryng.* 41: 422, June, 1932.) No specific organism has ever been isolated. It may occur at any age but is common in children.

Chronic bronchitis is, in my opinion, really *bronchiectasis*, almost without exception. I have seen many hundreds of these cases and only once or twice have I ever failed to demonstrate this. The origin is a chronic nasal infection, sinus disease, atrophic rhinitis, etc., and the sequence of events is that the infective material from the nose continuously infects and reinfects the bronchial tube which goes through stages of recurrent acute bronchitis, chronic bronchitis, and weakening of the walls of the bronchi with the production of bronchiectasis.

Objection has been made to this idea on the grounds that the cough reflex of the larynx interposes an insuperable barrier to the passage of material from above downward. But this objection does not take into account the continuous seeping of septic material down the back of the pharynx nor the relaxation and sucking and snorting that occur during sleep. It is a process that covers years. Mullin and Ryder (*Tr. Mid-West Sec. Amer. Laryng., Rhin. and Otol. Soc.*, Feb., 1920) have shown experimentally that it is possible to produce lesions in the lungs by the inhalation of fluids in the nose. (Clendening: *Chronic Nasal Infection, Chronic Broncho-atrial Infection and Perennial Bronchial Asthma*, *Ann. Clin. Med.* 3: No. 3, Sept., 1924.)

Bronchiectasis is a very common disease. No statistics give any idea of its incidence because it is not reportable; the patients are seldom hospitalized on that diagnosis; it is masked as a form of exitus by arteriosclerosis and other degenerative diseases; but mostly because until a practitioner gets his eyes open to the clinical picture, it is usually not recognized.* I have known a

*U. S. Public Health reports give as cause of death at ages 40 to 44, 0.03 persons per 100,000 dying of chronic bronchitis; 0.2763 at ages 60-64 and 3.32 at ages 80-84, but these give no conception of the numbers who suffer a lifelong invalidism and die under a different diagnosis.

skillful practitioner of internal medicine, himself the victim of the condition for years, perfectly incredulous and indignant when the diagnosis was suggested to him.

The organisms responsible may be any, but sooner or later in most cases the Vincent group makes its appearance. This condition is then called *spirochetal disease of the lung* or by amateurs, syphilis of the lung, because it often gives a 2 plus Wassermann and responds to arsenical and iodide therapy.

Bronchiectasis is almost always of very slow progression. In the early stages the patients complain of catching cold repeatedly and frequently. The "cold" very gradually becomes continuous with expectoration and cough. Temperature is not noticeable unless a carefully continuous chart is made. The patients suffer from drafts and cold weather; this symptom becomes increasingly annoying to all warm-blooded companions. I have known a patient to take an aspirin tablet before setting out on a round of golf with the temperature at 101° F., so he would perspire. The temperature of the skin is lower than that of others. Clubbing of the fingers in some degree and with progression is present in 90 per cent of cases. Particularly noticeable is a slight cyanosis, or rather, cyanotic pallor of the skin and fingernails. Eighty per cent of the patients are underweight and maintain their weight with difficulty, although rapid weight loss is not the rule. The muscles are particularly stringy and weak and myototic irritability of the muscles of the chest or the biceps is easily elicited.

Physical signs in the chest in an uncomplicated case are few. There may be some sonorous or sibilant râles or subcrepitant râles at periods of exacerbation but these need to be searched out. Nor does the roentgenogram show anything much except some hilar lineation that can easily be explained away. Indeed, even at autopsy it is easy to overlook the multiple minute areas of bronchial dilatation. Lipiodal injections, in my experience, are not much more revelatory than the plain x-ray. Hemoptysis occurs; in the Brompton Hospital series of 25 autopsies 80 per cent had hemorrhage, but it is a sign of an advanced process.

The pathologic division of dilatation of the bronchi into saccular, cylindrical, or fusiform is not very helpful. In all cases all of these forms may be found. The terminal cases are saccular. The emphasis should be put on recognizing the condition early or recognizing there is such an entity, as much can be done to make them comfortable with change to a mild climate and regular postural drainage and radical nasal surgery.

The diagnosis rests on the picture of the middle-aged or elderly valetudinarian who is always hawking, coughing, spitting and complaining of drafts and catching colds.

Bronchiectasis is not always diffuse but may involve a single lower lobe. If this can be proved by lipiodal injection, I believe lobectomy is indicated, radical as that sounds. (See Chapman and Wiggins: Circumscribed and Isolated Bronchiectasis, *Ann. Int. Med.* 14: No. 11, May, 1941.) Upper lobe bron-

chiectasis has been described, but only as a complication of tuberculosis. (Rubin and Newman: Upper Lobe Bronchiectasis, *Am. J. M. Sc.* 186: No. 5, Nov., 1933.)

COMPLICATIONS—Lung abscess may occur with no other perceptible etiology than bronchiectasis. (Kinghorn and Meyer: Bronchiectatic Lung Abscess, *J. A. M. A.* 79: No. 24, Dec 9, 1922.) Hypertrophic osteo-arthritis may range from the changes in the terminal phalanges which result in clubbed toes and fingers to a generalized crippling involvement of a large part of the skeletal system.

DIFFERENTIAL DIAGNOSIS.—The most frequent form of bronchiectasis in the early and middle stages, such as I have just described, is seldom correctly diagnosed because the profession has not become acutely focused on its existence. The stupidest and most brutal mistake made is to put these persons down as neurotics or hypochondriacs.

Syphilis of the lung is also a favorite diagnosis in the early and middle stages because of the false positive serology the spirochetal infection gives and the improvement under arsenical therapy. They may be mistaken for tuberculosis and we have many reports of the number of patients in tuberculosis sanatoria who have been there a long time and who really have bronchiectasis or lung abscess.

Fibrinous bronchitis consists of the formation of a fibrinous membrane, and a fibrinous cast of the bronchial tree may be coughed up. The only way the diagnosis may be made is by the appearance of this cast. Theories as to why a fibrinous mucoid secretion should be formed range from a local metabolic disturbance of the mucous membrane similar to the mucous membrane of the colon which causes mucous casts to a break in the bronchial mucous membrane allowing highly coagulable mucus to form. There is no specific bacterial etiology: cases must be distinguished from diphtheritic involvement of the trachea and bronchi. The signs are of a croupy dyspnea, inspiratory in character, cough which is very tight, loosening up when the casts are expelled, Charcot-Leyden crystals or Curschmann's spirals in the sputum and eosinophiles suggesting an association with bronchial asthma. The duration is from a few days to a week or more. Recovery occurs in most cases despite the alarming appearance of the patient. (See I. Chandler Walker: *Am. J. M. Sc.* 159: No. 6, June, 1920.)

Bronchitis fibrosa obliterans, described by Lange in 1901, although separately described in most texts, is nothing more than a form of bronchopneumonia. It is characterized by intense cyanosis and dyspnea with areas of râles on auscultation. The etiology has been stated to be inhalation of poisonous fumes and secondary to measles, whooping cough, pneumonia, and the aspiration of foreign bodies. At autopsy there are numerous small grayish-white nodules scattered through the lungs which may grossly be mistaken for miliary tuberculosis.

Broncholithiasis.—Spitting up stones during a coughing fit has been known since the days of Aristotle. Although sometimes referred to as osseous,

the concretions are really nothing more than calcium deposits that have been laid down in lymph nodes and inflammatory spots in the lung and have ulcerated into a bronchus and hence made their exit. They may be of nearly any size, from a small bead to that of a cherry, may be hard or soft, smooth, rough, or mammillated. Most of them naturally are associated with cured or quiescent tuberculosis. Pritchard (*Arch. Int. Med.* 32: 259, 1923) found an incidence of two cases among 7000 patients at Battle Creek Sanitarium. Lloyd (*Am. J. M. Sc.* 179: No. 5, May, 1930) collected 33 cases from the literature, but it is much commoner than this would indicate. The troublesome and humiliating cases are those in which an adult begins to cough in paroxysms as bad as those of whooping cough, frequently recurrent or nearly continuous and finally coughs up a stone. Elliott's case (*J. A. M. A.* 79: No. 16, Oct. 14, 1922) coughed for a month and finally coughed up 60 concretions at daily or tri-daily or weekly intervals over a period of more than a year. Complications are notably infrequent and the prognosis is generally good. Such patients have been treated for asthma, "recurrent flu" and nearly every imaginable respiratory disease.

Foreign Bodies in the Bronchi.—With the great improvement in bronchoscopic technique and ability to remove foreign bodies, the responsibility of the general practitioner, internist, and pediatrician to recognize them early before complications, such as lung abscess, have occurred is an increasing obligation.

It is hardly necessary here to record the large variety of foreign bodies which may pass the larynx. Some of them are indeed mysteries, as much so as that of a boa constrictor's swallowing a pig.

But, and this should be emphasized, equally mysterious is the ease and comfort with which they go past. Indeed, a young child might say with perfect honesty and good faith that the object he was holding in his mouth must have dropped on the floor because he did not feel anything slip down his throat, and yet on x-ray examination a toy automobile or railroad locomotive is found in the throat.

A professional colleague had a personal experience which is very illuminating on this point. He was walking up and down a room idly and, as he is the first to insist, foolishly tapping his teeth with an ordinary pin. Suddenly he found the pin was gone and a thorough search of the floor did not discover it. He had the inspiration of having a chest x-ray made, and there was the pin in the right primary bronchus. He had not felt the slightest sensation as a strong inspiration had sucked it out of his fingers and past his glottis.

Of course, this silent invasion is not a universal experience and with larger objects there is usually a well-remembered, even alarming episode of choking, gagging, and wheezing when the entrance is made. But Dr. McCrae wrote of a case where "there was no definite history as to when the foreign body, which was an atomizer tip, had been aspirated. The patient knew nothing of it, but on searching his memory remembered about eighteen months before, a tip had disappeared. This particular patient had been thought to have tuberculosis."

Few cases long remain silent after the aspiration. The great diversity of position of different foreign bodies, however, makes the catalogue of signs

difficult. One substance may plug a bronchus, causing atelectasis, and again an object may plug a bronchus for a time and later allow air to pass in so that x-ray films taken at two different times show a puzzling lack of agreement. A sharp object may perforate a bronchial wall. Commonest of all perhaps is to set up an irritation which causes severe paroxysms of coughing, wheezing and dyspnea. Dr. Chevalier Jackson (*Am. J. M. Sc.* 156 No. 5, Nov., 1918) described the "asthmatoïd wheeze" as somewhat similar to the wheezing heard when the ear is placed to the open mouth of an asthmatic patient, but drier and less associated with the sound of râles than is the asthma case. It is elicited by placing the ear in front of the patient's mouth, and it occurs during expiration. It is more likely to be produced by angular bodies, such as a bone, nut shell, grain of corn, than by a body which occludes a bronchus. It occurs in about 50 per cent of cases. Another somewhat distinctive sign is that of the presence of fine "tissue paper" râles heard with the stethoscope over a small area.

Change of signs and symptoms in a short interval is remarked by all observers. It is due undoubtedly to change of position of the body. This changeability is partly due to the shifting bronchial movements and secretions. "The normal bronchial movements are probably not fully realized by anyone who has never looked through a bronchoscope. It is an awe-inspiring sight. The bronchi are not rigid like gas pipes. They expand, contract, elongate, shorten; they bulge out, hinge in, bend and twist to an astonishing degree." (Jackson: *Am. J. M. Sc.* 165: No. 3, March, 1923.)

Sooner or later, if not removed, a foreign body in a bronchus acts as a sequestrum and sets up a localized area of necrosis or abscess formation. They are then often mistaken for tuberculosis. About 10 or 15 per cent of foreign bodies cannot be recognized on the x-ray; usually those in the later stage when the secretions or abscess has obscured the offender.

On physical examination of the chest one may find atelectasis, localized dullness and râles, limited expansion, prolonged expiration of bronchial quality, wheezing, sonorous and sibilant râles, or silence. (See McCrea: *Am. J. M. Sc.* 159: No. 3, Mar., 1920.)

Arachidic bronchitis (Jackson and Spence: *J. A. M. A.* 73: 672, 1919) is an especially dangerous form of foreign body inhalation due to bits of peanut shells in fragments, although other nuts produce the same changes. These set up an edematous purulent tracheo-bronchitis with fulminating onset, high fever, severe toxemia and signs of pneumonia. There is a great variety of râles, the majority being coarse and bubbling. A bronchus may be plugged by the secretion, and the lobe thus obstructed appears as a drowned lung.

Bronchiogenic Carcinoma.—See p. 424, pulmonary neoplasms.

Bronchial Asthma.—W. S. Miller worked out the musculature of the bronchioles in detail. It suffices for clinicians to know that they are invested with involuntary muscles which can either constrict or relax their lumina, and that they are under the influence of both the vagus, stimulation of which contracts them, and sympathetic nerves, stimulation of which relaxes them. The muscles

terminate in the bronchioles and do not extend over the alveoli. These muscles are very sensitive to the action of certain substances which we have come to call allergens, namely, the pollen of certain plants, the emanations of certain animals, foods, dusts, and miscellaneous substances. The action seems to be on the muscles themselves, at least as suggested by the experiments of Auer and Lewis who found that anaphylactic shock with status asthmaticus could be induced after the vagi are sectioned.

When this occurs the bronchiolar muscles contract and narrow the lumen of the passage, producing a form of respiratory distress called asthma. The difficulty is in expiration in most cases, in getting the breath out, although inspiration is not always free. W. S. Miller thought the bronchiolar muscles more active in expiration. The signs are great distress and discomfort, immobility of the body, varying degrees of cyanosis, pallor and clamminess of the skin, and the production of loud wheezing sounds, especially in expiration. In severe attacks these can be heard without the stethoscope, in the same room, in fact, in the same house with the patient. With the stethoscope they are easily identified all over the chest as sonorous and sibilant râles. The chest is resonant or possibly hyperresonant to percussion, the pulse is usually surprisingly good, and the heart sounds, provided they can be heard, are strong and clear.

It is a most mysterious state of the body. The professional allergists, to my mind, have not explained it at all. The best book that was ever written on the subject is that of Henry Hyde Salter *On Asthma* (the second edition, printed in 1868). Salter himself had cat asthma: "the cause, the proximity of the domestic cat: the symptoms are very similar to those of hay fever; some asthma would present itself if I were sitting in the chair and the cat sleeping on the hearth rug: most of all when they are in the lap purring. The influence seems to be stronger in kittens. . . . The effects of this poisoning are consequent on touch, or puncture. The eyes, lips and cheeks are susceptible of the effect of touch, but a puncture of the claw affects equally any part of the surface of the body. . . . The wound from a claw is always surrounded by a white hard elevation or wheal."

Salter described hay asthma, horse asthma, rabbit asthma, food asthma. "Asthmatics are generally dyspeptics," he said, and, "I succeeded in completely preventing the fit by forbidding the patients to take meat," and there is, "as much asthma in a mouthful of decayed Stilton cheese as in a whole dinner." He described all the things that the allergists have been smirkingly discovering for thirty years, and there is really more valuable therapeutics in his little volume than in the combined literature of the modern golden age of biochemistry. He even described the asthmatic physique and identified it on the bus and in the street.

Is asthma always allergic?

Well, in the first place we know that there are asthmatic states in which the cause is mechanical—pressure on the trachea from aneurysm, mediastinal growth or foreign body in the trachea or bronchi—or so-called cardiac asthma

in which there is wheezing or severe bronchitis or emphysema which produces sonorous and sibilant râles. This group will be remembered by the clinician but does not enter into the discussion of the question whether all asthma is allergic.

The argument that all asthma is due to allergy foundered on the rock of the specificity of skin tests. When I was a young allergist and a leader of the robber band, the great enthusiasm, the prime credo was on the fact that anyone with asthma would show a specific skin reaction if only you found the right allergen. I do not know exactly when this antinomianism began to break down: I suppose it was about the time when some rich patients with asthma began to appear in the allergists' offices. But break down it did, and we now hear that a great many patients with asthma do not show any skin reaction at all because they are sensitive to so many allergens. This is where I leave the fold. There are, I hold, a great many examples of asthma that are not due to allergy either chemical, physical, or any other kind. The largest number are due to chronic proliferative infection of the mucosa of the bronchial tubes which not only narrow the lumen of the tubes but also render the muscles more sensitive to spasm. The only cases of bronchial asthma that have ever come to autopsy were found to have just this condition. (Huber and Koessler: *The Pathology of Bronchial Asthma*, Arch. Int. Med. 30: No. 6, Dec., 1922, and Craig: Arch. Int. Med. 67: 399, Feb., 1941.) In many of these cases there has been long associated nasal pathology: the origin of the chronic hyperplasia of mucus is the same as that described above under bronchiectasis. For some reason some cases respond to nasal infection, not by pus formation in the bronchi, but by a chronic proliferative process of the mucosa.

Syphilis of the Trachea and Bronchi.—The incidence of this condition has not been collected of late years. In 1903 Conner collected 128 cases and Lord in 1915 (*Diseases of the Bronchi, Lungs and Pleura*) found 2 instances in 3,000 autopsies at the Massachusetts General Hospital. Tracheitis of mild degree is part of the roseola of syphilis. Late manifestations consist of either ulceration of the trachea or a bronchus or a gumma of the chondral elements. After a period of substernal soreness, coughing, wheezing and perhaps hemoptysis, the gumma may be absorbed. Or it may continue to destruction. Fortunately, for the susceptibilities of clinicians, this last complication is rare. One of the most horrible human spectacles I have ever been called upon to observe was a man in extremis with a complete collapse of his trachea from this cause.

C. Diseases of the Lungs

Tuberculosis of the respiratory tract was once so prevalent that it was a commonplace to say that every adult had once had some tuberculosis. The mortality from tuberculosis, however, has shown a steady downward trend all over the world for seventy-five years, and with it one may assume the incidence of infection has declined. In the United States the death rate from pulmonary tuberculosis in 1900 was 182 per 100,000; in 1935 it was 50 per 100,000. Nor is tuberculosis any longer universal among children. Taking the tuberculin test as a guide, it is found that among infants and children 5.6 per cent react

(Dickey and Seitz: *Am. Rev. Tuberc.* 23: Jan., 1931). In the pre-school age 14 to 20 per cent reacted (Dickey and Seitz, *op. cit.*). In the school age from five to ten years there were 54 per cent reactors and from ten to fifteen, 77 per cent reactors. Among high school students 79 per cent reacted (Heatherington, McPhedran, Landis and Opie: *Arch. Int. Med.* 48: Nov., 1931) and among adults percentages range from 25 to 100 per cent, largely depending on whether a rural or an urban group was tested.

The incidence of clinical tuberculosis depends upon race, economic status, occupation, rural or urban residence, and to a certain extent on sex. The range is indicated by the death rate, which is a good guide to incidence: in Buffalo in the Negro population the death rate in 1936 was 506 per 100,000, while among the white population it was 59 per 100,000.

We are dealing, then, with a sufficiently prevalent, albeit declining, disease. I suppose the modern conception of the diagnosis of tuberculosis is a Public Health program to go out into the population, force a survey, detect and segregate all the active cases rather than let them by chance drift into the hands of the diagnostician. With the idea of this program I entirely agree. It would, in the course of time, nearly eliminate tuberculosis from the earth but is not yet practical, because it is too expensive and the public is not yet sufficiently educated to cooperate.

It is not within the scope of this book to describe the bacteriology, epidemiology, or immunity of tuberculosis. The bacillus has a human, a bovine, and an avian form, but with the modern careful inspection of dairies the bovine form has nearly disappeared in this country, and the avian form was always a rarity, even a theory. For practical purposes all human tuberculosis is spread by direct contact from one infected human to another.

The disease takes many forms even if we confine ourselves entirely to the pulmonary forms. It is a lifelong disease in 99 per cent of cases, infection occurring in childhood and the disease taking one form in childhood and changing to something entirely different in adult life.

The primary lesion of Ghon or Ranke occurs usually in early childhood and consists of a single lymphatic, granuloma surrounded by satellite granuloma in the center of lung tissue. In the course of time it becomes sufficiently indurated or calcified to be made out on the x-ray. From the time of this primary inoculation the course may be varied—the primary focus may become entirely calcified and inert. Or it may extend gradually by lymphatic channels to the lymph nodes of the mediastinum. Or it may cause generalized childhood tuberculosis, such as peritonitis or meningitis. Or it may cause perifocal bronchopulmonary tuberculosis. Or it may cause pleuritis with effusion, with hardly any pulmonary involvement at all. Or it may result in miliary tuberculosis.

The onset of the adult form is the invasion from the tracheobronchial glands to the pulmonary acinar tissue with either acute tuberculous pneumonia (rare), or chronic caseous exudate tuberculosis, the common form of tuberculosis of the lungs, which may remain localized for years or may form cavities and wide caseous degeneration.

In diagnosis the x-ray has supplanted all other means. Physical findings are unreliable and even in the most skillful hands are liable to mistakes of omission. The tuberculous process may lie so deep that no signs are evident, even to the most skillful percussion and auscultation. No tuberculin test is satisfactory because none overcomes the objection that in the older patients it does not differentiate the active from the quiescent case. The examination for tubercle bacilli is a matter of chance and leads to many errors of omission. Fortunately the x-ray, provided the clinician be familiar with the protein pathologic possibilities of tuberculosis, renders a reliable diagnosis in nearly 100 per cent of cases.

Childhood Tuberculosis.—Perhaps the most important single element in the diagnosis of childhood tuberculosis is the knowledge of contact. The contact may be a highly unsuspected person—grandfather with a chronic cough—or, as in several cases known to me, a parent with extensive tuberculosis and not one single sign or symptom.

The symptoms which indicate childhood tuberculosis are peculiarly and tragically likely to be those which either disregard or prefer to explain on the ground of some pleasant fiction—the child is of a nervous temperament, his family was of a slender build, he plays hard, he has a fever, he has a nervous cough, he has never quite recovered from the whooping cough or measles. Pathologically there may be paratracheal, perihilus or peribronchial lymph nodes, or there may be parenchymal changes in the lungs, or pleura, or there may be both lymph node and parenchymal changes. The symptoms admittedly in a child do not pointedly obtrude themselves on the attention and they may so fluctuate with periods of good health as to be deceptive. The cough, whether brassy or not, of paratracheal and peribronchial lymph node enlargement, the persistent underweight rather than loss of weight, and the periods of nervousness alternating with prostrating fatigue are none of them especially obtrusive. Only if by accident the temperature is taken daily for a while is the fever discovered.

When the symptoms have become sufficiently obtrusive to demand confirmation by physical examination, the greatest reliability should be put on the tuberculin test and the x-ray. Ordinary physical diagnosis is perfectly worthless. Even if a practitioner is able to make out some dullness that might be mediastinal lymph node enlargement or some hyperresonant breathing or râles, he can never be sure enough to risk an argument with a skeptical patient. D'Espino's sign is thoroughly unreliable. I speak with some weight in this matter because I managed a Public Health Service in tuberculosis for several years in days before the x-ray, and I thoroughly fooled myself about the value of these procedures.

This is one place in medicine, however, where the tuberculin test is really valuable. Any of the skin tests may be used; the Mantoux intradermal test is the most sensitive (0.1 c.c. of a 1 to 1,000 dilution O.T.). The von Pirquet, using straight undiluted Old Tuberculin and scarifying a small skin area in skilled hands is painless. The Moro ointment test is the least sensitive and for that reason for some cases the best.

Combined with this an x-ray film gives the final word in diagnosis and should be done early so that subsequent x-rays can be used for comparison.

Miliary tuberculosis may be a serious diagnostic puzzle. It resembles any continued fever. The onset is usually abrupt with chills and fever and prostration. The chest may be full of fine, crepitant râles. X-ray films usually show an abundance of fine, miliary shadows.

Acute caseous bronchopneumonia (galloping consumption) resembles a pneumonia very closely and for that reason may be puzzling. The examination of the sputum, the absence of herpes labialis, the low leucocyte count, and the somewhat prolonged course may one or the other be the only thing to throw the clinician on the right track.

The adult form of *chronic caseous pulmonary tuberculosis*, the commonly seen form of the disease may be to all intents and purposes asymptomatic. We have all heard or seen instances of apparently perfect physical specimens of manhood, even star athletes, who had on examination a considerable invasion.

The *classic symptomatology* is cough, expectoration, loss of weight, pallor, hemoptysis, fatigue, repeated colds, night sweats, chills, amenorrhea, etc. Williams and Hill (J. A. M. A. 93: No. 8, Aug. 24, 1929) listed the appearance of symptoms, ranking them in importance as bearing on the seeking of medical advice as follows:

1. Cough.
2. Loss of weight, early morning fatigue, loss of strength.
3. Expectoration, frequent colds.
4. Loss of appetite, indigestion.
5. Dry pleurisy, pain in chest.
6. Elevation of temperature.
7. Shortness of breath.
8. Night sweats.
9. Spitting of blood, or copious hemorrhage.
10. Chills.
11. Rapid pulse.
12. Amenorrhea.
13. Fistula.

No short account of the physical signs of pulmonary tuberculosis is possible on account of the infinite variety of the lesions both in nature and location—from the early primary exudation through the stages of productive exudate, caseation, fibrous changes and cavity formation. The pioneers of physical diagnosis, such as Skoda, Traube, Wintrich, Williams, Grocco, etc., made their reputation on the minute description of signs in all the varied pathologic conditions of the disease. For two reasons all that has become outmoded. First, because most of the signs applied to late pathologic changes, and our only hope for restoring these patients to health is to make a positive diagnosis in the early stage. Second, the x-ray has proved so much more valuable than even the keenest diagnostician that the niceties of physical diagnosis in pulmonary tuberculosis is hardly worth cultivating.

The physical diagnostician has only to conceive of either one of two pathologic forms of lesion in early active tuberculosis. The first is *exudative*

which is the response of the tissue to tuberculous antigen, with exudate of small or considerable extent, little or no tissue destruction, and sooner or later absorption of the exudate. This produces possibly dullness, and increases vocal fremitus, high pitched prolonged expiration, and râles. The more usual form is *productive*. This lesion is in the terminal bronchiole. The alveolus is not much affected at first. The inflammatory fluid is exudate with cells and some tissue destruction. The primary physical sign is the râle on expiration and since it is produced in the bronchiole, not in the alveolus, it is coarser than the crepitant râle, as explained below. If the process is extensive enough there is harsh breathing, prolonged expiration and increased whispered voice, perhaps dullness on percussion and increased vocal fremitus, although these two latter indicate a somewhat older and more widespread process.

Physical examination is of more importance in determining the activity of the disease than in the mere making of the actual diagnosis of the existence of tuberculosis.

Inspection shows areas of muscle degeneration and wasting, with pleurisy or pneumothorax there will be contraction on the affected side.

Palpation yields little if anything.

Percussion is valuable only when positive. I have seen the most accomplished diagnosticians in the world declare a chest negative when it was riddled with advanced lesions.

Auscultation should be done with great thoroughness, especially the eliciting of râles. If this is done thoroughly and systematically, making the patient cough and inspire, the activity of the process can be determined. The râle of early tuberculosis is not the sharp, staccato crepitant râle of lobar pneumonia. It is coarser, longer in duration, and not so loud. It is by classification a subcrepitant râle.

The early tubercle, or tubercles, are usually below the clavicle—a fact to emphasize because physical diagnosticians have spent their youth hammering away and listening above the clavicle. The first involvement is below the clavicle: the apical branches of the bronchi are at right angles, whereas the subapical branches are at about twenty degree angulation which latter facilitates the entry of infected material to the subapical rather than the apical regions. (Bannen: *The Radiology of Pulmonary Tuberculosis*, William Wood and Co., 1937.)

Examination of the sputum should be done in all cases and when positive leaves no doubt about the specificity of the disease. If tubercle bacilli are not found in the sputum the gastric washings should be examined for them. Foley (Ann. Int. Med. 19: 629, Oct., 1943) found that in 639 cases in which tubercle bacilli were not found in the sputum, 187 (29.2 per cent) were found to have them in gastric washings.

The x-ray here also remains the court of last resort. I would never pronounce a negative diagnosis on a case which had not had an x-ray examination. (See pp. 705-712.)

DIFFERENTIAL DIAGNOSIS.—Tuberculosis sanatoria always have a few patients who have been there for years yet do not have tuberculosis. The majority of these are bronchiectasis, the form described above. Others are rare and the mistakes are unimportant. Bronchiogenic carcinoma, secondary metastases, emphysema, mycoses, actinomycosis, lung abscess, pneumoconiosis, and chronic passive congestion have all been mistaken for tuberculosis.

A serious error is for a diagnostician who has been impregnated with the necessity for the early diagnosis to make a positive diagnosis on insufficient grounds on a perfectly innocent person. This may impose a good deal of time out of a life and financial loss. The old doctrine of the importance of early diagnosis has lost much of its point since the introduction of surgical methods of treatment. It was Lawrason Brown, I believe, who said that the diagnosis of tuberculosis rested on five points: a history of hemoptysis of at least a dram of blood, a history of pleural effusion, tubercle bacilli in the sputum, a positive x-ray, and persistent râles after coughing. Any three are necessary for a diagnosis. At any rate they are starkly definite.

COMPLICATIONS OF PULMONARY TUBERCULOSIS.—*Hemoptysis* makes itself known immediately and evidently. *Pleural effusion* may occur almost silently indicating the necessity for frequent reexaminations, especially after any even apparently trivial febrile upset. The larynx should be examined at the first examination and some prophecy ventured as to how much likelihood there is of the process progressing. Few cases are spared some involvement but in only about 2 per cent of cases does it become serious.

Intestinal Tuberculosis.—In 230 autopsies on patients with pulmonary tuberculosis Goldberg found involvement of the digestive tract in 184. This indicates the incidence obviously among those in whom the disease is progressive and where little resistance is shown. All patients with open tuberculosis swallow the sputum to some extent, as is shown by the frequency with which tubercle bacilli are found in the gastric washings. The wonder is they do not all die of intestinal tuberculosis. The common locations are the ileum (83 per cent), the cecum (87 per cent), and the rectum, causing fistula (16 per cent). When pain and tenderness in the right lower quadrant with diarrhea alternating with constipation occur in the course of a case of chronic pulmonary tuberculosis, intestinal involvement may be suspected. Perforation is rare. Hemorrhage of gross amount is even rarer.

Spontaneous pneumothorax may be the first indication of the existence of tuberculosis. Only about half the cases of spontaneous pneumothorax, however, are tuberculous in origin. Other causes are emphysema, hemorrhagic infarct, lung abscess, and some remain forever mysteries. The rupture of the air into the pleura may be brought on by sneezing, coughing, straining at stool, or any sort of exertion or injury. In about three-quarters of the cases the onset is accompanied by such severe pain and dyspnea that examination is demanded and the diagnosis promptly made. The signs differ with the pathology. If there is simply a small pin-point hole in the lung that is immediately collapsed by pressure on the pleural side, the striking sign is complete

absence of heart sounds on auscultation; besides there is limitation of breathing on inspection, absence of vocal fremitus, and a peculiar percussion note that is almost dullness. With a pleurobronchial fistula there is amphoric breathing. With hydropneumothorax or pyopneumothorax there is dullness over the fluid, shifting on position, possibly succussion splash, and metallic tinkling. The coin sound is made with the help of an attendant who places a coin flat against the chest wall and taps it with the edge of another coin; the examiner on the opposite side of the chest listens with the stethoscope and the tapping sound is distinctly audible through a pneumothorax cavity as a ringing, metallic reverberation, poorly, if at all through lung tissue.

Again, the final resort in diagnosis of pneumothorax is the x-ray.

Initial Infection in Adult Life.—The modern public health program of tuberculosis is carried out on the basis of the pathology as outlined above—the infection is in childhood and can be detected in the childhood form in grade school or in more adult form in high school and college. Case finding is important because the infected child can be removed from the group which he might infect. This is an ideal scheme which cannot always be worked out practically, but it is approaching universal application. The question arises whether infection ever occurs primarily in adult life. Does a nurse or a medical student or an attendant in a tuberculosis sanatorium run any risk of infection? This violates our theoretical conceptions but apparently it does occur. It has been shown in tuberculosis sanatoria where nurses are examined when they enter for training and are found to be negative that some of them later are found to have well-developed adult tuberculosis. The best explanation of this that I have seen is that by Ornstein and Myerowitz (*Quart. Bull., Sea View Hosp.* 6: No. 5, Apr., 1941) which is as follows:

“Primary tuberculosis infection is very common among student nurses, and this first phase of tuberculous infection is often followed by actual pulmonary disease.

“This frequency of both tuberculous infection and tuberculous disease in student nurses has been the subject for much debate, but in the past decade the increasing accumulation of literature points conclusively to the fact that the student nurse uninfected on entering the training school quickly shows evidence of tuberculous infection by her change from a negative skin tuberculin reaction to a positive one. Very few students remain nonreactors at the completion of the three years of training.

“Pulmonary tuberculosis occurs frequently enough in this same group of students to raise the question whether or not this disease is more frequent here than in other similar age groups of young females. When tuberculosis became an occupational disease in the State of New York, it stimulated widespread interest in the subject of tuberculosis among student and graduate nurses. To avoid any confusion over the terms infection and disease, the two terms should be clearly defined at this point.

“When one says that a positive tuberculin reaction indicates nothing more than ‘tuberculous infection,’ an incorrect interpretation of the events has been made. By ‘tuberculous infection’ is meant that the human has gone through the primary phase of tuberculous disease. This phase of tuberculosis is characterized by a mild tuberculous disease of the organ involved, together with its draining lymph vessels and nodes, that goes on to healing, and in

which resolution, fibrosis, and calcification all play important roles. In over 99 per cent of individuals infected with this form of tuberculosis, healing occurs after which this can no longer be called tuberculous disease. However, this primary phase of tuberculosis produces in the tissues a sensitivity or allergy to the tubercle bacilli and their products. Further implantation of tubercle bacilli into these sensitized tissues causes more severe and destructive reactions than occurs in primary tuberculous disease. This infection of sensitized tissue is called 'reinfection tuberculosis' and is characterized by marked destructive changes in the organ involved and accompanied by marked toxemia with progression, often on to a fatal ending. The positive tuberculin reaction thus indicates that tuberculous infection has taken place, but does not distinguish between primary and reinfection tuberculosis.

"It has been pointed out that the sensitivity of the tissues to the tubercle bacilli and its products, which appears with the primary phase of infection, plays the important role in subsequent changes which happen on implantation anew of tubercle bacilli. Severe inflammatory and destructive changes occur which may become a serious threat to the very life of the person involved. With the above in mind, we cannot neglect the change of negative tuberculin reactors to positive ones. A group of young women who had so far in life escaped tuberculous infection have now become sensitized to tuberculo-proteins so that with any new implantation, a serious fatal disease is possible. And furthermore, the opportunities for this implantation of tubercle bacilli have become many times greater than occurs in other environments."

A number of articles on the subject have appeared as follows:

Collins and McMillan: Tuberculosis and the Student Nurse, *Canad. Pub. Health J.* 31: No. 12, Dec., 1940. Herman, Baetjer and Doull: Tuberculous Infection in Medical Students, *Bull. Johns Hopkins Hosp.* 51: 41, 1932. Hetherington, McPhedran, Landis and Opie: Tuberculosis Among Medical and Other University Students, *Arch. Int. Med.* 55: No. 5, May, 1935. Soper and Amberson: Pulmonary Tuberculosis in Young Adults, *Am. Review Tuberc.* 39: 9, Jan., 1939.

THE PNEUMONIAS

Pneumonia is an inflammation of the alveolar structure of the lungs. It is an acute disease of sudden onset, short duration, and more or less abrupt termination. Two forms are sufficiently distinct, pathologically, to be separated. Lobar (croupous or fibrinous) pneumonia is usually a specific disease caused by some variety of the pneumococcus. The tissue reaction is quite characteristic, consisting of a fibrinous exudate in all the alveoli of one or more lobes. The trachea, bronchi, and bronchioles remain remarkably free from the infection. The onset is abrupt and more than in bronchopneumonia the termination is also likely to be abrupt—by crisis—although this is not always apparent. The duration of the disease may be from two to fourteen days, usually about seven or eight.

The diagnosis of lobar pneumonia is one of the simplest in medicine. Sudden onset, fever, leucocytosis, chill, herpes, evident profound prostration, rapid pulse and respirations alone are sufficient to distinguish it. The physical signs have from time immemorial been divided into four stages. This is at times called old fashioned, but that is no reason to abandon it:

Stage of engorgement.—Pathologically there is congestion of the vessels and little exudate in the alveoli. The local signs may be very few. In fact,

this is the only stage in which the signs may cause puzzlement. There is, in fact, in many cases, a curious suspension of all signs in the chest—even the respiratory murmur seems to have disappeared—in itself a suspicious circumstance.

Stage of red hepatization—When the exudate begins to form in the alveoli, there are the local signs of dullness and at first crepitant râles, later, as the exudate completely fills the alveoli, bronchial breathing. Palpation will be limited because the patient is usually too sick to cooperate.

Stage of gray hepatization.—The exudate begins to liquefy and digest and return of crepitation (crepitus redux) is found as well as many combinations of bronchial breathing, dullness, sonorous and sibilant râles and mucus and submucus râles.

Stage of resolution.—During this period the signs change from hour to hour approaching normal all over the chest.

The diagnosis of lobar pneumonia is best made on the general signs—fever, pulse, respiration, dyspnea that can be heard all over the room, the general appearance of the patient—rather than fussily moving him about to obtain physical sounds. The x-ray has no place in the diagnosis of pneumonia. The trouble and movement involved in obtaining an x-ray film are distinctly detrimental to the patient. The physician who cannot make a diagnosis of lobar pneumonia without an x-ray should be given a broom and allowed to sweep the streets—a vocation that suits his talents. The physician who orders an x-ray as a routine on pneumonia patients is beyond the contempt of my pen.

The physician's duty when he has made a diagnosis of pneumonia is, however, not entirely over. He should obtain sputum and determine what strain of pneumococcus is present. This, at least, is part of his duty if he is contemplating giving antipneumococcic serum. With sulfonamide compounds and penicillin nearly entirely supplanting serum in treatment, this duty becomes one depending on circumstances.

Bronchopneumonia (lobular, catarrhal pneumonia or capillary bronchitis) is much less of a distinct disease entity than lobar pneumonia. Pathologically the small bronchioles share with alveoli in the inflammation. There is no distinct exudate into the alveolus. Various lobules throughout all lungs are affected rather than all the alveoli of one lobe. The onset is not remarkably abrupt and the course and symptoms are subject to wide variations. Nor is there any specific etiologic agent present. It may follow measles, indeed is the serious sequel to many diseases. It is the pneumonia of influenza. It may be caused by nearly any organism.

Fifty years ago lobar pneumonia was the common type. Now bronchopneumonia outnumbers the cases of lobar pneumonia.

The diagnosis of bronchopneumonia is seldom any more difficult than that of lobar pneumonia. The condition may follow an illness such as measles or influenza or just a severe bronchitis, but the prostration is just as great. Leucocytosis, high fever, chill, and dyspnea are not the rule but about this there is no rule. Physical signs of the most infinite variety are found in the chest.

Dullness is not usually present, however, nor increased vocal fremitus nor bronchial breathing. But every variety of râle may be found scattered throughout the chest.

The same thing that was said of the use of the x-ray in lobar pneumonia applies in bronchopneumonia.

Virus pneumonia is a form described by Goodpasture and colleagues (J. Ped. 18: 440, April, 1941) and by Longcope (Practitioner 148: 1-8, Jan., 1942). The cases of Goodpasture and others occurred only in infants, in epidemic form, secondary to whooping cough and measles; inclusion bodies were found in the cells of the bronchial epithelium. Longcope's cases occurred in adults, were characterized by racking cough, little or no sputum, high fever and slow pulse, leucopenia, roentgen shadows out of all proportion to physical signs and a prolonged course terminating by lysis. The few cases I have seen labeled virus pneumonia have been indistinguishable from cases of lobular pneumonia.

A number of articles in the literature from 1941 to 1944 reported atypical pneumonia and virus pneumonia as interchangeable terms. The clinical picture, while variable, is sufficiently standardized to lead to the supposition that the etiologic factor when determined will prove to be identical for all. The onset is quite slow. The patient at first thinks he has a cold and then as it does not clear up, and he becomes more prostrated and weaker, he seeks medical advice. The temperature seldom remains elevated all through the twenty-four hours. It is highest the first two days of observation and continues with some temperature elevation at some time during the day for several days. The mean duration of fever in Brethauer and Thompson's series (Ann. Int. Med. 20: No. 6, June, 1944) was six days. The highest temperature recorded was 105° F., the average was 102° to 103° F. The sputum is thick, tenacious, mucopurulent. Physical examination does not reveal frank consolidation in most cases, but râles are present, more or less abundant. The x-ray shows shadows going from the hilus toward the parenchyma, dense at the hilus. The shadows are seldom very dense; they appear trabeculated like tuberculosis. The shadows in Brethauer and Thompson's cases were hilar in 20 cases, lower half in 29, upper half in 8, both lungs in 9, patchy in 25, confluent in 24. Migrating shadows appear. The blood shows normal white cell count or slight leucopenia. The duration of fever is on the average two weeks. The mortality is reported as 1 per cent (Goodrich and Bradford: Am. J. M. Sc. 204: 163, 1942). Response to sulfonamide drugs or penicillin is poor.

COMPLICATIONS OF THE PNEUMONIAS.—The common complication of lobar pneumonia is empyema of the pleura. There is probably no equally serious condition which is so frequently missed and mismanaged by competent practitioners. For the reason that most of these cases are never recorded, I doubt whether we have the slightest idea of the incidence of empyema in pneumonia. It varies, of course, in different epidemics, but the incidence in any epidemic is at least 10 per cent and in some 30 per cent, but since the advent of the sulfonamides and penicillin these percentages have been materially decreased. In bronchopneumonia the incidence is likely to be much higher. Any patient

who has had a pneumonia, who on recovery begins to have an afternoon fever, should be suspected of having empyema until proved otherwise. Yet these patients are allowed to drag on under the asinine diagnosis of unresolved pneumonia until the physician loses track of them and they turn up years later with a bronchopleural fistula or amyloid disease.

Although most of them can be located by physical sign, the x-ray is a great help in the diagnosis. The prohibition against the use of the x-ray in the acute stage disappears when fever has persisted in a case of pneumonia over two weeks. If you cannot find out with a stethoscope, you had better employ an x-ray.

The physical signs of empyema are boardlike flatness and absence of voice and breath sounds. It were well if all such antiquated monstrosities as Grocco's triangle, Ellis' S-shaped case, Garland's triangle, and Skodaic resonance were forever banished from the textbooks and the classroom. Half the time even an instructor cannot convincingly demonstrate them, for the very good reason that half to three-quarters of the time they do not exist. Empyema fluids are always bound by pleural adhesions and do not move on change of position of the patient. They almost never displace the heart.

Occasionally, very occasionally, voice sounds and breathing can be heard through a pleural empyema and even more occasionally vocal fremitus makes its way through. These phenomena occur, I suppose, when the fluid is pushed up against a bronchus or flattens an area of lung against bronchus, but they are so rare as to be negligible.

An empyema usually forms over the spot where the pneumonia reaches the pleura. There is another factor, that of gravitation, so since most patients are in the recumbent position, the empyema forms in the posterior part of the chest. At least that is the only explanation I have for the statistical fact that most of them are formed there. But they may do queer things. Fig. 37 shows an empyema which formed in the front of the chest just under the clavicle and had to be drained through the pectoralis muscle.

An interlobar empyema is a puzzling affair. It may happen in the course of tuberculosis. I never saw it happen on the left side but between the upper and the middle and lower lobes of the right lung it forms and spreads out on the flat surface like butter between two pieces of bread. It produces absolutely no physical signs but on the x-ray, on account of the oblique rays of direction of light, it spreads out as a large, flat triangular shadow.

When an empyema has gone unrecognized, undiscovered, and allowed to follow its own wayward way, bizarre results can occur. The commonest thing is for the encapsulated pus to burrow through the lung, reach a bronchus, and drain itself that way. It is a very imperfect way because it never drains completely, and the results of long absorption of pus sooner or later manifest themselves—clubbed fingers, pallor, amyloidosis. But I have seen an encapsulated empyema cooped up without breaking out become sterile and occupy an entire pleural cavity for ten years. The lung, when it was freed by a decortication, was in as pristine a condition as when it was born. Of course, the pus may burrow anywhere and form interocular nests in the lungs. I

wish I could say these late results were less frequent now that the x-ray has become more routine but the roentgenologists seem to know as little about the habits of empyemata as my colleagues, the physical diagnosticians.

Unresolved Pneumonia.—I do not know what this is. Theoretically it applies only to lobar pneumonia and means that when the process which is initiated by the release of antibodies which digest the exudate the alveoli gets about so far it stops and the exudate does not go on to complete digestion—which is nonsense. My experience with what might reasonably be called unresolved pneumonia is that the exudate becomes infected with a different organism and a new inflammatory process is set up. I have seen very few such cases. The trouble is that it is still used to salve the physician's feelings when he has an empyema to deal with. Ninety-nine per cent of the cases called unresolved pneumonia which I have seen are really empyema.

Gangrene of the Lung.—The incidence is given as 3 per cent, but in my experience this is away too high. It occurs mostly in the aged or debilitated. The gangrene is septic, due to saprophytic organisms. In the typical case the horribly fetid nature of the breath makes the diagnosis. I never knew a patient to recover.

Abscess of the Lung.—This occurs about as frequently as gangrene and the process is of the same nature. Multiple small abscesses which coalesce are the rule.

Metastatic Infection.—Endocarditis, pericarditis, meningitis are dealt with under their appropriate sections.

Syphilis of the Lung.—A tracheitis is part of the secondary stage of syphilis and the cough may be annoying. Congenital white pneumonia is of pathologic interest only as the infants are nearly always stillborn. Gummata occur rarely in the lung and can be seen with the x-ray. The form of syphilis of the lung about which there is any discussion is none of these. It is described variously as a fibrosis, as a triangular form of dullness extending from the hilus to the pleura, associated with cough and sometimes with hemoptysis. It has been said that this is very much more frequent than is supposed, that it is frequently overlooked, and that from 1 to 11 per cent of those admitted to tuberculosis sanatoria are really pulmonary syphilis. Warthin reported spirocheta in lungs so frequently as to be almost constant. Others have said what Warthin saw were elastic fibrils.

Personally, I do not believe that syphilis of the lung ever occurs. Most of the diagnostic reports base the diagnosis on a therapeutic result and indicate that the real condition is a spirochetal Vincent's infection. I have been to many pathologic museums and asked to see their specimens of syphilis of the lung. Even the museum curators are doubtful of their specimens. In the published reports autopsies are conspicuous by their absence. For years I faithfully examined patients that someone said had syphilis of the lung. I finally found the case that set all my doubts at rest. It was a man who had a chronic fibrosis at the left base. At a large clinic his diagnosis had been syphilis of the lung. He died and sections from the diseased lung were sent to ten or twelve pathologists for an opinion. About three-quarters of them

said it was fibroid phthisis; a few said they did not know what it was, and one said it was syphilis, but he found no spirocheta. Now if that happens when you actually have the specimen under the microscope, how can you say there is such a thing clinically?

Cystic Disease of the Lungs.—These cases are congenital. The cysts may be so large as to cause death rapidly by asphyxiation. Or they may be so small as to go without symptoms throughout life. They may communicate with bronchi and if so, produce cough, expectoration, and hemoptysis. They can be made out on the x-ray plate. Physical signs vary so with the location, size, and other features of the cyst that they cannot be classified. (See Moorman: Congenital Cystic Disease of the Lungs, *Ann. Int. Med.* 7: No. 12, June, 1934. Bruce: *Acta med. Scandinav.* 102: 295, Nov. 4, 1939. Wood: Congenital Cystic Disease of the Lung, *J. A. M. A.* 105: No. 11, Sept. 15, 1934.)

Neoplasms of the Lung.—Secondary growths in the lung are very frequent. The general symptoms overshadow the local ones. Hemoptysis and dyspnea may occur and there are growths found by x-ray—that is the usual story—where they appear as multiple, nodular, rounded shadows. The most frequent primary site is the breast.

Primary tumors of lung (excluding the mediastinum) are bronchiogenic carcinoma of the lung, sarcoma, fibroma, and endothelioma of the pleura.

The commonest is the *bronchiogenic carcinoma*. The incidence is said to be increasing, but this is doubtful, the apparent increase being due to better methods of detection. Bon Glinski (*Deutsches Arch. f. klin. Med.* 185: 73, Sept., 1939) in 18,145 autopsies on persons over twenty found 2,695 carcinomata of which 104 were primary pulmonary carcinomata.

Bronchiogenic carcinoma in which the growth occludes a bronchus large or small is the one which presents clinically. The symptoms are, in order of frequency, cough, sputum, dyspnea, chest pain, hemoptysis, wheezing, weakness, weight loss, dysphagia, hoarseness, edema of face and neck, unilateral edema of extremities. The onset is usually insidious. The physical signs are limitation of motion on affected side, dullness on percussion, and diminished or absent breath sounds (on account of atelectasis). Effusion into the pleural cavity often occurs. Rabin and Henhof (*J. Thoracic Surg.* 4: 147, Dec., 1934) classify them into *hilar*, from main or first division bronchi, *peripheral*, arising from smaller bronchi, but usually invading the parenchyma, and *diffuse nodular carcinomatosis*, involving both lungs. (See White, Cohen, Guassi and Price: *J. A. M. A.* 118: No. 11, March 14, 1942.)

A puzzling condition is atelectasis of a lobe or large part of the lung which may clear up and then recur; it is, of course, due to alternating plugging of the bronchus by the tumor, but unless the diagnostician is prepared for it, it may puzzle him.

Bronchiogenic carcinoma may produce central necrosis and abscess formation and for all practical purposes give the signs of a lung abscess.

The other variety of carcinoma of the lung is the infiltrating adenocarcinoma. The cell type is either adenoid, squamous, or undifferentiated (large

polyhedral, or oat type, or round cell). Of these the oat cell carcinoma is the most frequent. The growth usually begins at the hilus and extends into the lung parenchyma. Cough, dyspnea, hemoptysis, and pain are the four cardinal signs and symptoms. Fetter (Carcinoma of the Lung, *Ann. Int. Med.* 18: No. 6, June, 1943) found that in 31 proved cases the diagnosis was established by bronchoscopic examination and biopsy in 14, by necropsy in 11, by biopsy from a metastasis in 3, by exploratory thoracotomy in 2, and by finding tumor cells in the pleural fluid in 1 case.

Primary tumors at the apex may produce a syndrome described by Pancoast. They are primary from alveolar tissue, and the symptoms are due to irritation of spinal and sympathetic nerves—paresthesias of the skin of the arms and shoulders, paralysis of the recurrent laryngeal or phrenic nerves and Horner's syndrome—myosis, ptosis, exophthalmos—and unilateral absence of sweating.

Abscess of the lung is secondary to (1) the inspiration of septic material during anesthesia, especially in operations on tonsils, adenoids, etc., but may follow general anesthesia with any operation; (2) inspiration of a foreign body; (3) development and spread of a bronchiectatic cavity; (4) pneumonia; (5) aspiration of liquids; (6) infection and necrosis of a neoplasm; (7) septic embolism; (8) wounds, trauma. What may be called a primary lung abscess is due to inspiration of septic material from a Vincent's infection of the mouth or from some infection of the nose.

Freedman (*New England J. Med.* 218: 663, 1938), reviewing 276 cases, found the causes as follows: pneumonia (of all kinds) 38 per cent; upper respiratory tract infection 26 per cent; postoperative of operations on upper respiratory tract (tonsillectomy and dental extractions) 10 per cent; postoperative (mainly abdominal) 15 per cent; unknown, or miscellaneous, the balance.

The relation of spirocheta and fusiform bacilli is debatable. Some believe them *secondary invaders*, but Smith (*Tubercle*, 9: 420, 1928) found them in the walls of abscesses.

The common belief that lung abscess tends to form in the lower lobes is disproved by Fisher and Finney's figures (*Bull. Johns Hopkins Hosp.* 66: 263, May, 1940) which show that 47 out of their 88 cases were in upper or middle lobes.

Symptoms in Flicke's series were: cough, 99 per cent; hemoptysis, 45 per cent; fever, 62 per cent; pain, 71 per cent. Signs were: profuse sputum, 95 per cent (foul in 80); blood tinged or gross, 54 per cent; dullness, 60 per cent; râles, 58 per cent.

Symptoms and signs of lung abscess depend upon its location and size. Most of them are too deeply placed to produce physical signs. Profuse expectoration, which may or may not be foul, is the sign that tips off the diagnostician. Fever and night sweats and hemoptysis very often lead to a diagnosis of tuberculosis. Physical signs include some combination of dullness,

râles, bronchial or amphoric breathing, and egophony. The x-ray is always of positive aid: serial plates taken a few days or a week apart showing development are especially valuable.

Pneumoconiosis consists in the changes that occur in the lungs as the result of the inhalation of various dusts. Coal, stone, and iron dusts are the usual ones encountered. The civilian physician seldom sees any but a sporadic case and the industrial physician, since the installation of preventive methods, sees cases only when accident or carelessness have allowed them to occur.

The only one with clinical significance that is at all common is silicosis. Silica is found in so many rocks that any dust or mining trade would carry the hazard.

Two pathologic forms may be distinguished for clinical purposes: the deposit of silica nodules without and with added infection. Simple silicosis consists in the formation around silicate particles of nodules more or less uniformly distributed throughout the lung. They are avascular and usually situated at the entrance to a lobule. "They punctuate the perivascular lymphatic pathways between the alveoli and the pleura at the periphery of the lung. They are frequently associated with a perilymphatic fibrosis." (McCann in Cecil's *Textbook of Medicine*). As the process advances these nodules coalesce, forming very serious derangements to the smooth functioning of the lung.

Silicosis with infection may include the imposition of tuberculosis, "miner's consumption." Gardiner has estimated that at least 75 per cent of people who develop silicosis die of tuberculosis. Nonspecific infection may, however, occur.

DIAGNOSIS.—The outstanding symptom of a well-developed simple silicosis is dyspnea. In a patient with marked dyspnea that is not asthma, is not associated with edema and therefore, unlikely to be cardiac, the only two diagnoses likely are silicosis and emphysema. With the development of infection, cough and expectoration occur. The vital capacity of patients with silicosis is like that of those with advanced pulmonary failure. Long-continued pneumoconiosis leads to *cor pulmonale*.

Diagnosis depends on a history of occupational exposure and characteristic x-ray findings. There are no specific physical signs either for the simple form which shows various degrees of wheezing or the infected form which is no different from tuberculosis.

Emphysema is a degenerative condition of the lungs in which the alveoli become distended and lose their elasticity; usually rupture of contiguous walls occurs so that several alveoli are merged. It is generally classified into compensatory or localized atrophic or senile and hypertrophic or obstructive and acute vascular emphysema, as in mountain climbers, glass blowers, etc. The compensatory can be readily disposed of: it is a temporary condition in which part of the lung enlarges during pneumonia, pleural effusion, or pneumothorax in order to allow normal or nearly normal respiration to be carried on. The atrophic form is usually found in senility, as part of the atrophic change that occurs elsewhere in the body with advancing years. The alveolar walls be-

come atrophic and lose their elasticity. In contrast to true emphysema the lungs are small and retracted. (Hamman: *Oxford Medicine*.) Hypertrophic emphysema shows large lungs at autopsy that dilate and spread over the heart and other viscera. The air spaces, particularly at the periphery are large—sometimes as large as hen's eggs. They cannot conceivably carry out any respiratory functions and often the capillaries are destroyed. There is evidence that these bullae do not communicate with any bronchioles. Loet (Arch. Int. Med. 45: No. 3, 1930) did not believe there was any essential difference between the atrophic and hypertrophic form. While a great deal of paper has been sullied trying to explain emphysema, it seems evident that two elements are largely responsible for most cases: a constitutional tendency for the alveoli to break down like poor rubber, or poor arteries, and an occupation that puts a great deal of strain on them. Glass blowers, blowers of wind instruments, those who carry heavy loads, those with nasal obstructions, laryngeal obstruction, and tracheal obstruction (from goiter, for instance) are the predestined victims of the disease.

DIAGNOSIS.—The outstanding sign is dyspnea. The typical picture is that of an elderly person with a big chest, slight cyanosis, and slow movements. The condition is seldom uncomplicated by cardiac, arterial, or renal disease. The signs are universal sonorous and sibilant râles and hyperresonance which the examiner usually has to read into the picture. Cabot wrote, "Whether there is any clinical picture or any physical signs recognizable as corresponding to these lesions (dilatation and breakdown of the alveolar walls) I am quite uncertain. In 1921 I thought I could recognize emphysema. The following facts have disillusioned me. In 12 cases diagnosed as emphysema at the Massachusetts General Hospital, only three showed emphysema at post mortem. On the other hand, of 153 cases demonstrated as emphysema only 7 were recognized during life." The longer I have thought about it, the more impression this statement of Cabot's has made on me. I do not remember ever having made the diagnosis of emphysema as a single entity in my life: it is always associated with heart failure or something else. By the very nature of their examination pathologists are likely to remove all gross evidence of emphysema.

The vanishing lung is the dramatic name given to some cases of bullous emphysema in which the bullae became so large and coalescent that the lung structure practically disappeared. The x-ray plates of these cases are remarkable specimens showing over one lobe or one whole chest no lung markings whatever. (See Burke: *The Vanishing Lung*, Radiology 28: 367, 1937. Allison: *Ann. Int. Med.* 117: No. 5, July, 1942.)

Atelectasis of the Lungs.—Collapse of a considerable area of lung tissue follows obstruction of a bronchus by foreign body, blood clot, mucus, bronchiogenic cancer, lymph node, etc. So far as symptoms are concerned the chest may be silent or there may be a more or less acute onset of dyspnea, cough, pain, cyanosis and in cases of very acute onset, shock. The physical signs are absence of respiratory movements on the affected side, dullness on percussion, absence of vocal fremitus, breath sounds or voice sounds. The

heart is likely to be displaced toward the affected side. The x-ray shows a shadow and paralysis of the diaphragm. A striking feature is that the obstruction may give way spontaneously and, as in the case of bronchiogenic carcinoma with a valvelike growth, reclose the bronchus with complete change of all signs from day to day.

Massive Postoperative Collapse of the Lungs.—About the time of World War I the literature began to be full of a new condition with the above name. W. Pasteur (*Internat. Jour. Med. Sci.*, 1890) had, however, described it some time before. But in 1908 in the Bradshaw Lecture before the Royal College of Physicians and in 1914 he described it with more emphasis and it became a very popular subject for discussion. The best theory of causation is that there is a paralysis of the diaphragm. The conception is that the lung then ceases to function; there is sudden shock with drowned lung from secretions. I have never seen any cases of postoperative massive pulmonary collapse that were not due to demonstrable bronchial obstruction. The first case I ever saw occurred after a tonsillectomy, and I thought the patient had a pleural effusion. A few hours later he coughed up a plug of cotton moulded exactly to the form of a bronchus, and his symptoms disappeared. Later, a surgeon was telling me about his case of massive collapse and I related my experience; with some surprise he said, "Well, my patient coughed up a piece of gauze and then the symptoms left us." Leopold (*Am. J. M. Sc.* 167: No. 3, March, 1924) says, "Complete bronchial obstruction offers the best explanation for the cause of the condition."

Postradiation Pleuropneumonitis.—After high voltage therapy applied to the chest, the lungs and pleura may show signs of acute infection resembling bronchopneumonia and including pleurisy with effusion.

Hydatid disease of the lung is very rare except in the proper geographic distribution: Iceland, Norway, Greece, and the Argentine. Of visceral involvement the lung is second after the liver in frequency, producing about 10 per cent of all cases. The most important symptom is hemoptysis. Pain, dyspnea, and pressure symptoms appear as the growth proceeds. Rupture of the cyst into a bronchus occurs in about half the cases. Physical signs depend upon size and proximity of the cyst to the chest wall. The x-ray plate shows a most characteristic smooth globular shadow.

Actinomycosis of the lungs is a very rare occurrence in this country. Sanford and Voelker (*Arch. Surg.* 11: 809, Dec., 1925) found records of only 670 cases, 42 per cent being in children under fifteen years of age. The cases are usually mistaken for tuberculosis and the symptoms and signs greatly resemble the chronic form. Diagnosis is made only when actinomyces granules are found in the sputum or when, as is usually the case, the process ulcerates through the chest wall, causing caries of a rib.

Mycoses of the Lung.—A number of organisms, such as streptothrix, aspergillus, torula (yeast), monilia, etc., are occasionally described as causing chronic pulmonary infection. Usually these imitate tuberculosis, indeed are

often a secondary infection on top of it. The diagnosis is made in almost every instance by accident and for the practitioner to miss the diagnosis is no disgrace whatever.

Pulmonary blastomycosis is somewhat more common than the others. Most of the patients have lived in unsanitary surroundings. There are characteristic abscessed, ulcerative, or verrucous skin lesions. The respiratory involvement may be acute, resembling a bronchopneumonia, or chronic, resembling tuberculosis.

Pulmonary Sporotrichosis.—This fungus begins as a pustule on the fingers or hand and spreads up the lymph nodes of the arm. The habitat of the organism is on the surface of fruit, so is found most frequently in such food haulers. The pulmonary manifestations are characterized by a peculiar mucilage-like sputum and considerable dyspnea. The fungus produces a fibrotic condition of the lungs. There is an agglutination test. In connection with skin lesions chronic or acute pulmonary symptoms should be suspected of sporotrichosis or blastomycosis until proved otherwise, because both respond very well to iodide of potash.

Coccidioidomycosis (coccidioidal granuloma).—The cause is a mold which produces lesions in the skin and in the lung. The granuloma in the lung closely resembles the tubercle histologically. In this country most of the cases were reported from the San Joaquin Valley, California, until Farness (J. A. M. A. 116: No. 16, April 19, 1941) showed that it was quite widespread and not uncommon in our western states. "It behooves physicians in every case of pulmonic infection not readily diagnosed to consider coccidioides." (Farness.) The lesion in the lung is a granuloma with no characteristic distribution but usually in the middle lobe: it throws a dense shadow on the x-ray film. The characteristic organism can be recovered from the sputum or stomach washings. The disease may involve any organ in the body, bones, lymph nodes, and meninges being most commonly affected after the skin and lungs. Cattle, sheep, and dogs carry it. The onset may suggest a severe cold or influenza with cough, sputum, bloody sputum, pleural pain, chills, fever, etc. Eosinophilia is frequent. Skin lesions of erythema nodosum or general erythema type occur, preceding or following the pulmonary onset. One death occurred in a series of 354 cases, but if the case runs on to the generalized form, the prognosis is bad. (Winn and Johnson: *Ann. Int. Med.* 17: No. 3, Sept., 1942; Stiles and Davis: *J. A. M. A.* 119: No. 10, July 4, 1942.)

Psittacosis is an infectious disease which is transmitted from household pets, parrots, lovebirds, and finches to man. It seems not to be transmitted from man to man. It affects the liver, spleen, and lungs predominantly, the last producing a bronchopneumonia which spreads from the hilus to the periphery, but does not affect the pleura. There are slow pulse and respiratory rates and usually a leucopenia. Since restrictions have been placed on the importation of infected birds, it has practically disappeared in North America. (See Favour: *Am. J. M. Sc.* 205: No. 2, Feb., 1942.)

Pulmonary tularemia may exist as a clinical entity according to Kennedy (*J. A. M. A.* 118: No. 10, March 7, 1942). The patients have no skin lesions;

there is an initial chill and high fever, moderate leucocytosis, dullness, and râles over a limited area. Some patients give a history of contacts with rabbits. I have never recognized a case nor can I see from the descriptions how anybody could be expected to recognize one sufficiently to order an agglutination test.

D. Diseases of the Mediastinum

The mediastinum is often spoken of as if it were a structure. As a matter of fact, it is simply a locality. It is that part of the thoracic cavity between the sternum, the vertebrae, and the inner borders of the lungs. It has been divided by anatomists into four parts: the superior, anterior, median, and posterior mediastinum. The superior mediastinum, the part which is clinically most frequently interesting, lies above the pericardium. The anterior mediastinum is that part between the pericardium and the inside of the sternum, while the median and posterior mediastinum are respectively the parts between the layers of the pericardium and between the pericardium and the inside of the vertebral column.

The mediastinum contains the following structures: (1) the trachea, and part of the primary bronchi after their division, (2) the arch of the aorta, (3) certain large arteries—the innominate, the left common carotid and the left subclavian, as well as some smaller ones, (4) veins—the superior vena cava, and the innominate, (5) certain nerves, the phrenic, pneumogastric and recurrent laryngeal among them, (6) the esophagus, (7) the thoracic duct, (8) numerous lymph glands largely on the right side and near the right primary bronchus, (9) the thymus gland in childhood, and its remains in adult life, and (10) the thyroid gland may move into the mediastinum—substernal goiter.

W. S. Lemon (M. Clin. North America 5: No. 3, Nov., 1919) gave the following classification and localizing symptoms: *Classification of Mediastinal Growths.*

1. Benign neoplasms
2. Malignant neoplasms
3. Abnormally placed organs
 - (a) Substernal goiter
 - (b) Thymus
4. Hodgkin's disease
5. Lymphosarcoma
6. Tuberculosis
7. Pathologic conditions in the circulatory system
 - (a) Aortitis
 - (b) Dilatation of the aorta from pressure
 - (c) Mitral stenosis
 - (d) Cardiac hypertrophy
 - (e) Pericarditis with effusion
8. Pott's disease
9. Aneurysm of the thoracic aorta
10. Syphilis
 - (a) Gumma
 - (b) Syphilitic mediastinitis

To which may be added nonspecific mediastinitis and emphysema of the mediastinum.

COMMON PRESSURE SYMPTOMS AND SIGNS

1. Esophagus	Dysphagia (a) persistent when due to direct pressure (b) transient when due to irritation of the recurrent laryngeal nerve
2. Trachea	Brazen cough (gander cough) Dyspnea—often only on exertion Stridor with bellows breathing and indrawn manubrium sterni Bronchorrhea Hemoptysis
3. Root of lung and pleura	Difficult and insufficient aeration like phthisis Pulmonary collapse, consolidation, or chronic pneumonia May vary from time to time with variation in pressure
4. Nerve trunks	Neuralgic type of pain. Paroxysmal and intermittent
5. Pulmonary artery	Systolic murmur, dilated right heart
6. Superior vena cava	Cyanosis—edema of head and neck and upper extremities Collaterals do not pulsate as in cardiac disease
7. Right pulmonary veins	Hydrothorax and collapse of lung
8. Thoracic duct	Marasmus
9. Cardiac plexus	Anginal attacks—simulating angina pectoris. Third cervical to third dorsal segmental distribution
10. Sympathetic nerves	Dilated pupils, indicating irritation Contracted pupils, indicating paralysis No loss of reflex except in syphilis Unilateral sweating, flushing, or pallor
11. Vagus nerves	Dyspepsia, nausea, vomiting, dyspnea, hiccough
12. Recurrent laryngeal nerves	Hoarseness, aphonia, spasm or paralysis of the left vocal cord—suffocation
13. Right recurrent laryngeal nerves	Right cord paralysis
14. Phrenic nerves	Unilateral paralysis of the diaphragm. Pain about the neck just above the clavicle.

The collateral venous circulation which is set up when a mediastinal tumor compresses the superior vena cava is quite a remarkable sight. All the superficial veins of the chest and abdomen stand out. The collateral route is established by an anastomosis between the external mammary above with the superficial epigastric and the superficial circumflex iliac below.

The thymus attains its maximum growth at two years. It occupies the superior and anterior mediastinal spaces. At puberty it rapidly diminishes so that it remains in adult life a fibrous strand usually attached to the thyroid. Modern observers are inclined to doubt whether a persistent thymus can compress the trachea to produce thymic asthma. I confess I have never seen such a condition. But Chevalier Jackson has observed with the bronchoscope the compression of the trachea due to thymic enlargement, and Cratti (*J. A. M. A.* 60: No. 8, Feb. 22, 1913) has pictured the narrowed trachea in one of his cases. Equally doubtful has become the existence of a kind of endocrine state known as status thymicolymphaticus in which the individuals are lymphatic in character and sudden death may result from inadequate trauma.

Asthma coming on suddenly for the first time in an elderly individual should suggest compression of the trachea from Hodgkin's disease or aneurysm.

The symptoms of hyperthyroidism when there is no thyroid palpable in the neck should remind the diagnostician of the possibility of substernal goiter. When there is an accessory thyroid under the sternum which alone is active (as in one of Hosoi and Stewart's cases), the going is tough.

Spontaneous interstitial mediastinal emphysema was described by Hamman (Tr. A. Am. Physicians 52: 311, Sept., 1937). It may occur following trauma, the induction of pneumothorax, with spontaneous pneumothorax, following pneumonia, coughing, bronchoscopy, asthmatic attacks, the straining of labor pains or at stool. The symptoms and signs are:

Pain in the precordial area, which may simulate coronary disease.

Occurrence of a peculiar crunching, crackling sound synchronous with cardiac systole which may be audible to the patient or those about him.

In all diseases of the mediastinum the x-ray is quite indispensable. Percussion is usually accurate and valuable. Oliver's tracheal tug may be present with any mediastinal tumor adherent to the aorta.

The symptoms are likely to be mixed because pressure is put on more than one organ. Lockwood, Narr and Bell (J. Missouri M. A., Feb., 1937) have analyzed the symptoms in frequency as follows:

	PER CENT
Dyspnea	66
Cough	48
Pain	34
Dysphagia	27
Hoarseness	12
Vomiting	6
Sore throat	4
Choking	3
Anorexia	1

And the physical signs as follows:

	PER CENT
Superficial venous stasis	44
Enlarged lymph nodes	30
Cyanosis	29
Sputum	23
Weight loss	17
External tumor	17
Fever	13
Edema legs	10
Nerve paralysis	5

E. Diseases of the Diaphragm

As was intimated in the section on the diaphragm in the chapter on the x-ray, the principal obstacle to the diagnosis of the diseases of the diaphragm is failure to think of them. If the symptoms suggest a diaphragmatic hernia or a subphrenic abscess, the x-ray will in almost every instance confirm the diagnosis.

The conditions in which the history and physical examination may suggest diaphragmatic disease are subphrenic abscess and the various forms of diaphragmatic hernia.

Subphrenic Abscess.—Barnard has divided the spaces below the diaphragm into four intraperitoneal and two extraperitoneal areas. This classification is followed by most authors on the subject. The liver is suspended from the diaphragm by the falciform ligament which divides the general space between diaphragm and liver into a right and left part. The peritoneum reflected from the undersurface of the diaphragm spreads out from side to side, forming two lateral ligaments which subdivide these two primary areas into four, so that we have a right anterior intraperitoneal, a right posterior intraperitoneal, a left anterior, and a left posterior intraperitoneal space. The peritoneum spreads out, leaving uncovered a considerable area on the superior surface of the right lobe of the liver; this space partially separated into two divisions by the top of the small sac of the peritoneum constitutes Barnard's extraperitoneal spaces—right and left.

The signs of abscess formation in one or the other of these spaces will differ with the location of the abscess. Subphrenic infection should be suspected whenever an intra-abdominal infection is followed by a prolonged or unsatisfactory period of convalescence.

Hochberg (*Ann. Int. Med.* 17: 183, Aug., 1942) gives the origin of infection in his cases as follows:

	CASES
Liver and biliary passages	44
Appendix	29
Kidney	9
Stomach and duodenum	8
Pelvic inflammation	6
Furunculosis	2
Prostatic abscess	1

The abscess may rupture through the diaphragm and cause empyema or on into a bronchus, imitating a lung abscess.

The x-ray evidence of subphrenic abscess is largely inferential. The diaphragm on the affected side is high, sharply domed, and fixed. This especially applies to the right side where nine out of ten subphrenic abscesses are located. When abscess ruptures through the diaphragm into the pleura, the outline of the diaphragm is blurred, and the lower part of the thorax is obliterated by diffuse spiculated shadows—not sharp as the shadows of pleural effusion and empyema usually are.

Differential diagnosis must be made between subdiaphragmatic abscess and either pleural empyema or pleural effusion. The physical signs of dullness and absence of breath sounds may be much the same, due to the doming of the diaphragm and its flattening out over the posterior thoracic wall. The x-ray is not always of the greatest of help, although a sharp high diaphragmatic shadow, if present, points to subphrenic abscess. The use of pneumoperitoneum has been touted as a help to the diagnosis of subphrenic abscess. "A few pumpfuls of air injected into the abdominal cavity will rise to the top between the dome of the diaphragm and disclose any pathology present. Such small quantities of air have no tendency to interfere with the most delicate inflammatory adhesions and we have never seen any evidence of spread

of the infection. Subdiaphragmatic abscess cannot be definitely demonstrated in any other way." (L. R. Sante: *Principles of Roentgenological Interpretation*, Edwards Brothers, Ann Arbor, 1940.) We have had no experience with this method in subphrenic abscess.

A clear history which should point in the case of subphrenic abscess to previous appendicitis or peptic ulcer and in the case of empyema to previous pulmonary infection, together with the leucocyte count which should differentiate effusion from pyogenic collections, and finally exploratory needling which gives more information than anything else are more valuable as differential evidence than anything the x-ray furnishes.

The symptoms are usually vague—weakness, fatigue, loss of weight, fever, rarely chills, and unlocalized upper abdominal pain—are about all in the uncomplicated cases.

The signs may be of two general sorts, abdominal and thoracic, depending upon the anatomic location of the abscess. On the right side, which is the usual site, the abscess will point either abdominally in front at the right upper inner abdominal quadrant, or in the right lower thorax behind.

The abdominal signs are those of any intra-abdominal infection—rigidity, tenderness, leucocytosis, etc. The thoracic signs are due to the accumulation of an abscess in the posterior and anterior right intraperitoneal subphrenic space, pushing the diaphragm up, which can occur to an astonishing height, flattening the diaphragm out against the posterior thoracic wall, causing dullness and the absence of breath sounds.

Pleural effusion is the condition which must be differentiated most frequently from subphrenic abscess. Lockwood states, in a differential table, that the two diseases can be distinguished because pleurisy with effusion is more common following influenza or pneumonia, that it causes rapid respiration, that the temperature is not of the church steeple type, that the level of dullness changes on change of position of the patient, that the heart is frequently displaced, and that dyspnea and cyanosis are common. I regret that in my experience the matter is not so simple. Pleural effusion, of the type causing diagnostic doubt, is not a sequel of influenza or pneumonia; it seldom or never changes the respiration; usually being tuberculous in origin, it does cause a low morning and high evening temperature; the level of dullness never changes in uncomplicated (i.e., nonpneumothorax) cases of pleural effusion on change of position of the patient; the heart is seldom displaced; dyspnea is rare, and cyanosis almost unknown. The very points which make the diagnosis so puzzling are that, in both diseases there occurs dullness with absence of breath sounds over the back of the chest, without previous history of thoracic disease, with a septic type of fever, with no change of position of the level of dullness on change of position of the patient. In differential diagnosis the history is important, the connection of events from the original appendicitis or other intra-abdominal infection is usually clear. The radiograph shows a sharper level of the diaphragm than will occur in any type of pleural effusion. Perhaps the most valuable differential diagnostic method of all is the exploratory needling of the chest.

Ladd and Swan (New England J. Med. 229: No. 1, July, 1943) have reported 14 cases in children in which the infection was by extension from intra-abdominal sepsis in 9, metastatic in 4, traumatic in 1. Abdominal tumor is more frequently the important sign in children in this condition than in adults.

Diaphragmatic Hernia.—In the section on the x-ray we have noted the six weak spots in the diaphragm which may be the site of diaphragmatic hernia and also Mark's classification of diaphragmatic hernia. (See p. 729.)

Symptoms that have been described in the textbooks under the heading of cardiospasm should always make the clinician think of thoracic stomach, incompletely descended stomach, or short esophagus; in fact, some derangement by which part of the stomach is either permanently or intermittently in the thorax. Notable among these is the feeling that the food is still in the esophagus. It is not dysphagia, although that word is frequently used. There is a feeling of fullness in the thorax just in the region of the heart and then the feeling that it has moved down into the stomach; feelings, in fact, that are just exactly expressive of the very mechanical conditions present. Neither the terms *dysphagia* nor *regurgitation* cover the real nature of the symptoms. Thoracic stomach has been described as very rare, but if attention is paid to this symptom and the cases are carefully followed to the x-ray laboratory, I think it will be found quite frequently.

Root and Pritchett (Cleveland Clin. Quart. 5: No. 3, July, 1938) have listed the symptoms in their series as follows: cardiorespiratory symptoms—pain simulating angina, dyspnea and cyanosis while eating or shortly after eating—33 per cent; dysphagia, 33 per cent; symptoms simulating peptic ulcer, 40 per cent; symptoms simulating gall bladder disease, 25 per cent.

The physical signs of diaphragmatic hernial disease—that is, ordinary routine inspection, palpation, percussion, and auscultation—are practically nil. Only with large hiatus hernia will any be present, such as tympany on percussion, succussion splash, etc.

F. Diseases of the Pleura

The diseases of the pleura which we will consider here are:

1. Acute fibrinous pleurisy.
2. Pleural effusion.
3. Empyema of the pleura.
4. Hydrothorax—transudate of cardiac or renal failure.
5. Spontaneous pneumothorax, hydropneumothorax, pyopneumothorax, etc.
6. Chylothorax.
7. Tumors of the pleura.

All cases of inflammation of the pleura can theoretically go through several stages: first, forming a fibrinoplastic exudate which may resolve or which may go on to the formation of an effusion of clear fluid or the formation of pus. Pleuritis is probably never primary but always secondary to inflammation of

the lungs, even though this may not be evident at the time of the pleurisy at all. Primary pleurisy is, or at least so the evidence would seem to point, always tuberculous. Empyema, whether frank pus or the infective fluids of streptococcic infection, follows pneumonia.

Acute fibrinous pleurisy is an inflammation which rises apparently spontaneously with a pain or stitch in the side. There is often a reflex cough and usually fever, sometimes a chill at the onset. Physical examination shows on inspection limited excursion on the affected side, hyperpnea in about half the cases, no change on percussion, a possible fremitus on palpation, and pleural friction rub on auscultation in about 75 per cent of cases. In about half the cases there is a leucocytosis of 12,000, rarely more unless the pleurisy is in reality the herald of a lobar pneumonia. The x-ray is negative unless the exudate is quite thick.

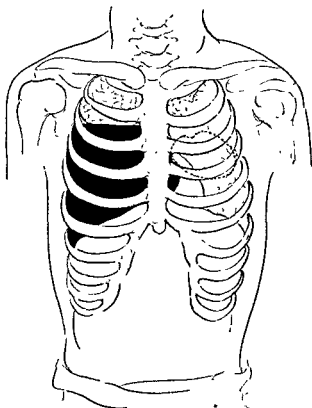


Fig. 35.—Popular but erroneous conception of the anatomy of pleural fluid. The fluid does not accumulate like water in a bucket with a definite upper fluid level (unless there is associated pneumothorax). The heart is not displaced.

There are few signs so frequently overlooked in clinical medicine as the pleural friction rub; it rivals the pericardial friction rub in this, but the characteristic pain of acute fibrinous pleurisy is so constant that diagnostic success is higher than in pericarditis.

The disease which most often confuses the diagnostician is herpes zoster in the period before the eruption. Pericarditis, the gastric crises of tabes,

spondylitis, angina pectoris, and intercostal neuritis (if any such entity exists) are the points for differential diagnosis.

Fulton and Hahn (*J. A. M. A.* 97: No. 26, Dec. 26, 1931) followed forty patients with dry pleurisy for seven years and found that in four pulmonary tuberculosis developed. While this is not as high a percentage as pleural effusion, I have always felt that acute fibrinous pleurisy had the same significance as pleural effusion; it is an early, usually abortive, manifestation of pulmonary tuberculosis.

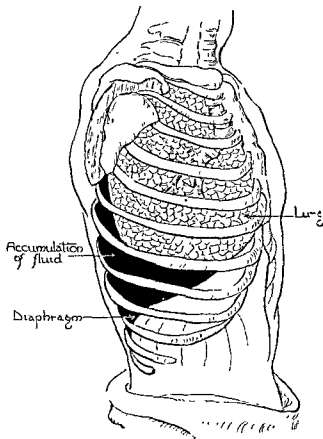


Fig. 36.—True anatomy of pleural fluid—either pleural effusion, or hydrothorax, or most cases of empyema. The fluid accumulates in the back of the chest, and is pushed up by the pneumatic pressure of the lung into the shape of a cone.

With the consideration of pleural effusion we had best take a preliminary survey of all forms of fluid in the pleural cavity. I began to hold iconoclastic views on this subject twenty-five years ago and have studied and confirmed my ideas repeatedly ever since, with the result that I disagree with many statements in the literature. This does not only include the textbook literature which has a notable tendency to be copied from one book to another, and also an unexplicable prejudice toward copying mistakes, but also the current literature, even the best of which I have found to be unreliable in that starting from false premises, observations are recorded which are plainly contrary to fact. For instance, an article in a thoroughly reputable journal published an

x-ray labelled "Note displacement of the heart from pleural effusion." There was actually no displacement of the heart whatever: it could not have better satisfied the requirements of a normal heart in size and position. The author's psychologic processes were apparently that he had been so saturated with the doctrine that the heart is displaced in pleural effusion that he put in the comment without making any independent observations on the subject.

Some of my iconoclasm are of no particular practical importance. Some of them, on the contrary, if not observed would and, in my experience, have, directly initiated a correct diagnosis. I have, for example, seen a physical diagnostician in the amphitheatre refuse to make a diagnosis of pleural effusion because the dullness did not shift on change of position of the patient, there was no displacement of the heart, and the intercostal spaces on the affected side did not bulge—all of which signs are the regular features of the condition.

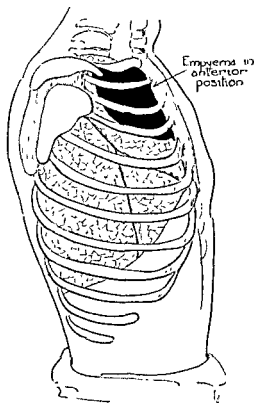


Fig. 37.—Empyema of peculiar distribution and location. This shows the fixation of empyema fluid caused by formation of pleural adhesions.

All of the hoary misconceptions of pleural fluids are based fundamentally on the primary misconception of the mechanics of their formation. In the first place the pleura is a serous membrane just as quick in forming limiting adhesions as the peritoneum. Second, the lung is constantly exerting pressure on the forming fluid, pressing it out into as thin a film as possible against the chest wall. Except in the case of accompanying pneumothorax—except when

air and fluid are mixed in the pleural cavity—the fluid never acts as does water in a bucket.

We read of “encysted empyema” or “encysted pleural fluid” as if it were an exception. Every pleural fluid which has the slightest degree of infectivity tends to become encysted and 99.5 per cent of them do and break out of their encystment only when they become so massive that they break through their adhesions or when trauma breaks them. An empyema will infiltrate through the lung and create a bronchial fistula before it will break its pleural adhesions—its encystment.

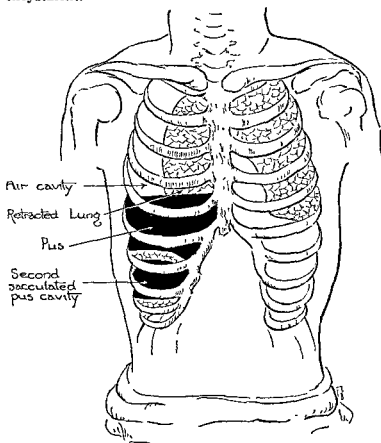


Fig. 38.—Fluid in the pleural cavity associated with pneumothorax. In this case there were two separate accumulations of pus. The upper collection has a definite fluid level, which could be demonstrated by percussion front and back.

Even transudates from heart failure tend to create limiting bands of pleural adhesions.

The sign of “the fluid moves on change of position of the patient” therefore, must be completely discarded. Only when air is also present in the pleural cavity can we look confidently for this sign.

The intercostal spaces do not bulge with pleural fluid. Taking our analogy again from the abdomen, an infectious fluid causes muscle spasm and the underlying pleura becomes thickened and the intercostal spaces are narrower and flatter than normal.

Displacement of the heart apex depends entirely on circumstances. A very massive effusion naturally tends more to displace it. A pleural effusion is almost never massive enough to displace the heart. Empyema displaces the heart only when it has set up strong retractive adhesions, and then it pulls the heart toward the side of the empyema. A pneumothorax displaces the heart when the pressure in the pneumothorax cavity rises: this occurs in spontaneous pneumothorax only when there is a flutter valve type of rupture in the lung, and air goes in but does not escape. In artificial pneumothorax, of course, the pressure is increased and even the whole mediastinum may be displaced.

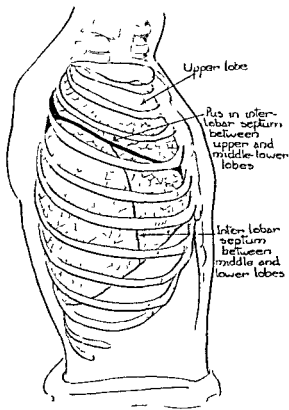


Fig. 33.—Interlobar empyema is almost impossible to demonstrate by physical signs, but it appears as a broad band in the x-ray plate.

The mechanism of formation of pleural effusion is as follows: The fluid usually accumulates in the lower part of the chest in the outer costophrenic angle. The fluid tends to gravitate there no matter where the site of infection in the pleura. As it accumulates, the patient is naturally sick and recumbent and it accumulates in the posterior part of the chest. It is constantly pressed out by the lungs so that it takes the form of a triangle with a narrow base and an extremely sharp apex. Therefore the triad of signs—dullness, absence of fremitus, and absence of breath sounds—occur only in the back. The height of the dullness and the height of the x-ray shadow do not represent a solid

accumulation of fluid but an ever-thinning layer spread out over the back. The upper level of the effusion can therefore seldom be definitely made out by percussion. The S-shaped line of Ellis exists only when the fluid rises in the outer side of the chest and lags along the vertebral border (which is the rule, but the S-shaped curve of Ellis is a vestigial structure in physical diagnosis and should be discarded from teaching and practice).

This thin accumulation of the fluid also accounts for the surprise the diagnostician may have when a tap returns only a few hundred cubic centimeters of fluid in a case which is dull up into the scapula.

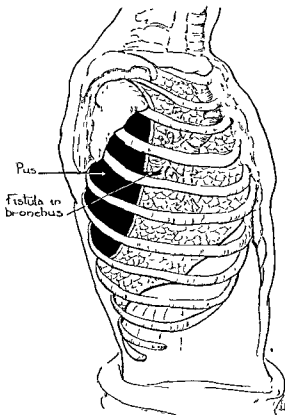


Fig. 46.—Pus in the chest cavity following pneumonia (empyema). After burrowing its way to the bronchus, it was coughed up. The emaciation, fever, and expectoration simulated tuberculosis.

Grocco's triangle occurs only when the accumulation of fluid is massive or when the accumulation is along the vertebral border. As a diagnostic sign it is completely passé.

Skodaic resonance above the fluid occurs also, depending on circumstances, and although perhaps the easiest of the accessory signs to demonstrate, adds little to our diagnostic judgment and should be forgotten.

Pleural effusion fluid has a feeble power of reaction on the pleura, and adhesions do not limit it markedly if it tends to become massive, but they do form, and eventually will hold the fluid upright along the back of the chest even if the patient is in the erect position.

Pneumococcic empyema fluid has a strong power of reaction on the pleura, hence it may form any place and is held encysted by adhesions. I know of no exception, when recovery has taken place, to the rule that empyema is pocketed by adhesions.

Streptococcic empyema fluid has a fairly strong power of reaction on the pleura (not as much as pneumococcic) and may wander more, but it is never free in the pleura and eventually becomes encysted.

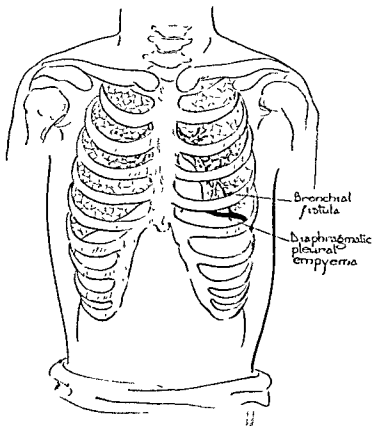


FIG. 41.—Empyema localized along the upper border of the diaphragm with bronchial fistula.

Hydrothorax transudates may do queer things. They form in the same way as pleural effusion fluids form, governed by the position of the patient and the pressure of the lung; therefore, they almost invariably rise higher in the back than in the front. But they do rise also in front, covering the lung all over with a rind of fluid. They change somewhat on change of position of the patient but sometimes in a surprising fashion. Figs. 100 and 105 (pp. 717-722) will show x-rays of a patient with a transudate first in the erect position and then lying on the side opposite from the fluid. Note that the fluid instead of moving along the mediastinal border finds less resistance by moving along under the roof of the chest.

Chylothorax fluid moves more readily than a transudate and tends more usually to come up to the expectations of mechanics.

Pleural effusion, when it occurs spontaneously and primarily (that is, without any known preceding pulmonary tuberculosis), is followed by the development of active pulmonary tuberculosis in about 30 per cent of cases. Generalized tuberculosis or meningitis may also follow. The more carefully a follow-up survey is done, the higher is found to be the proportion of cases developing tuberculosis. Gaards (J. A. M. A. 95: No. 4, July 26, 1930) found in a follow-up of 126 cases that 35 patients were dead, of which number 29 were certainly known to have had tuberculosis; 10 were ill with pulmonary tuberculosis, and 8 had recurrent trouble with lungs or pleura. "If a patient survives the original acute attack of pleurisy with effusion there is a good chance of complete recovery. If he survives the first three years, and particularly the first five years, his chances are excellent for complete recovery."

Spontaneous pneumothorax means a rupture of the lung and visceral pleura and the entrance of air into the pleural cavity. In over 75 per cent of cases the air does not remain alone in the cavity but is followed by the formation of serous fluid (hydropneumothorax), pus (pyopneumothorax), or a hemorrhage (hemopneumothorax). Pulmonary tuberculosis is the cause in at least 75 per cent of cases, some series going as high as 90 per cent. Almost half (48 per cent) of the patients are aged from twenty-one to thirty years; 34 per cent are from thirty-one to forty, and 12 per cent from eleven to twenty years.

Diagnosis is based on symptomatology, physical signs, and x-ray. The onset is usually sudden with pain followed by dyspnea, shock, and cyanosis. "In 10 per cent of cases there was a history of the patient suddenly raising a large quantity of sputum, a fact that should always arouse the suspicion that pneumothorax may have occurred." (Lemon and Barnes: J. Iowa M. Soc., March, 1922.) On the contrary, in tuberculous cases Gray (J. A. M. A. 76: No. 17, April 23, 1921) lists as one of the signs lessened cough and expectoration. The onset may be insidious or silent. (Pepper: Am. J. M. Sc. 143: 522, 1911.) *The immediate mortality in tuberculous cases is 70 per cent* (Palmer and Taft: J. A. M. A. 96: No. 9, Feb. 28, 1931).

If the rupture in the lung is in the form of a valve, air accumulates until the lung is completely collapsed. The heart and mediastinum are then displaced, interstitial mediastinal emphysema may even occur, but instances of these structures giving way entirely and allowing air to enter the opposite pleural cavity are of extreme rarity.

The physical signs of pneumothorax are numerous, reliable, and have been known since antiquity, as witness the eponym Hippocratic succussion. Inspection shows a bulging immobile chest on the affected side. Vocal fremitus is absent and the percussion note usually quite dull, since air under tension tends to rob the wall of the chest of its elasticity. Auscultation reveals distant or absent breath sounds. Metallic tinkling is rare, produced probably only when there is a fistulous lung opening below the level of fluid. Amphonic breathing may be heard. Hippocratic succussion is not always easy (or ad-

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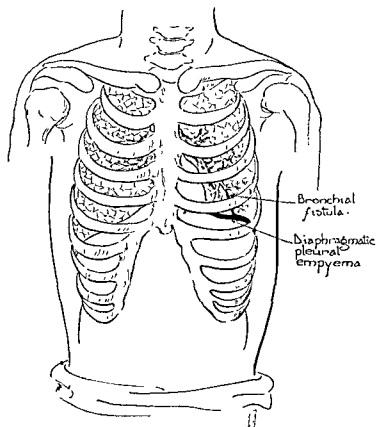


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visible considering how ill most of the patients are) to elicit. The coin test is probably the most reliable and constant of all the physical signs. An assistant stands in front of the patient while the examiner listens to the chest behind (and vice versa). The assistant presses a large coin flat against the chest wall and taps it gently with a smaller coin. The sound heard by the examiner is as of a pebble dropped in a well. In a normal chest no sound is heard.

The cause of nontuberculous or idiopathic spontaneous pneumothorax has puzzled all who have observed such cases. It is associated with emphysema, whooping cough, infarct, abscess, asthma, cystic lung, but in the majority of the cases no cause is ever found for it. In emphysematous lungs and in normal lungs blebs are often seen on the lung surface separated from the exterior by only a very thin film of tissue. Rupture of one of these seems the most reasonable explanation.

Chronic Pleurisy.—When an empyema or a pleural effusion goes unrecognized and is neglected, the fluid eventually becomes inspissated, sterile, and more or less absorbed. (Unless, as in the case of some empyemata, a bronchial fistula occurs.) This leads often to a very serious condition from deformity to the chest. It is never so extreme in pleural effusion as in empyema, but in any case leads to a considerable amount of deformity. Even calcification of the visceral and parietal pleura may occur with great contraction and rigidity of the chest wall. Extensive plastic surgery, such as decortication of the lung, may be required, and at best results are never completely restorative. This paragraph is put in as a warning toward early diagnosis and prompt evacuation of septic fluid. (See Eggers: Chronic Empyema, *Ann. Surg.*, Feb., 1923.)

Tumors of the Pleura.—The only primary malignant tumor of the pleura worth recording clinically is the one variously called endothelioma or mesothelioma or sarcoma. Even it is of the greatest rarity. Pathologists dispute as to its nature and terminology (the cells are unquestionably like the endothelial lining cells of blood vessels), but the important clinical fact is that it is a solid tumor and presents the sign of dullness on percussion, absence of fremitus and breath sounds, and a shadow on the x-ray. They are almost invariably mistaken at first for fluid, a justifiable and harmless mistake. (See Zecker: Mesothelioma of the Pleura, *Arch. Int. Med.* 34: No. 2, Aug., 1924.)

Tumors of the thoracic wall include osteoma, osteochondroma, fibroma, fibrosarcoma, benign giant cell tumors, osteogenic sarcoma, and Ewing's tumor. They are usually localized, not large, and reveal themselves readily in most cases as a swelling at some point in the thoracic cage. (See Brewer: Primary Intrathoracic Tumors, J. A. M. A. 121: No. 14, April 3, 1943.)

Chapter 10

EXAMINATION OF THE ABDOMEN

1. Peculiarities of the abdomen, anatomic and pathologic, as they affect physical diagnosis.
2. Routine plan for examination of the abdomen.
3. Methods of examination of the abdomen.
4. Relative frequency of abdominal diseases.
5. Presenting sign. General distention of the abdomen.
6. Presenting sign. Rigidity and tenderness of the abdomen.
7. Presenting sign. Abdominal hemorrhage.
8. Presenting sign. Localized tumor, rigidity or tenderness of the abdomen.
 - a. Upper left quadrant.
 - b. Upper right quadrant.
 - c. Lower right quadrant.
 - d. Lower left quadrant.

I. PECULIARITIES OF THE ABDOMEN, ANATOMIC AND PATHOLOGIC, AS THEY AFFECT PHYSICAL DIAGNOSIS

For the physical diagnostician the abdomen is particularly subject to inflammation and tumors (in the sense of swellings, not limited to neoplasms). The viscera of the abdomen are protected only by fascia and muscles, not by bone, as in the case of the thoracic viscera. Therefore, changes in the contour can be seen; tenderness, rigidity, and swellings can be felt. By the nature of the case, therefore, inspection and palpation will be the dependable methods for the physical diagnostician to cultivate in abdominal examination.

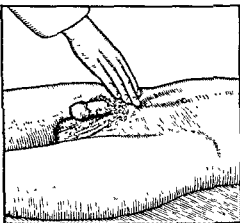
II. ROUTINE PLAN FOR EXAMINATION OF THE ABDOMEN

1. Inspection.—

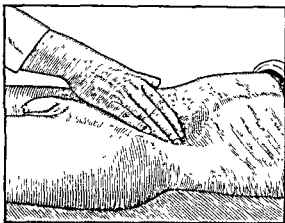
- a. Skin—linea albicantes, laparotomy scars, eruptions.
- b. Hernia—patient standing, coughing, and recumbent.
(For discussion see p. 287.)
- c. Visceroptotic habitus—patient standing.
- d. General shape of abdomen—patient standing and recumbent—distended, flat, rigid, scaphoid.
- e. Visible peristalsis.
- f. Masses.
- g. Umbilicus. (For discussion see p. 286.)

2. Palpation (standing, recumbent, in warm bath, and, if necessary, under anesthesia).—

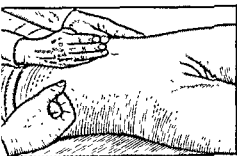
- a. For tenderness and rigidity—right and left rectus over entire course. Right and left flanks. Deep grip palpation over gall bladder.



Deep palpation of
Right Iliac Fossa.



Deep palpation of
Left Hypochondrium.



Elicitation of
Fluid Wave in
Suspected Ascites.



Deep palpation using both
hands; this distributes
pressure very evenly.

Fig. 42.—Palpation of the abdomen

- b. For spleen.
- c. For kidney—especially standing.
- d. For liver.
- e. For fluid in the peritoneal cavity.
- f. For distended bladder, stomach, colon.
- g. For tumors. If present, record location, size, shape, consistency, tenderness, pulsation, relationship to any organ.
 - (1) Left upper quadrant (pylorus, colon, intestines, kidney, spleen).
 - (2) Right upper quadrant (gall bladder, colon, intestines, liver, kidney).
 - (3) Right lower quadrant (appendiceal abscess, cecum, Meckel's diverticulum, intussusception, ovarian tumor).
 - (4) Left lower quadrant (sigmoid, ovary).
 - (5) Midline (uterus, pregnancy, fibroid, etc.).

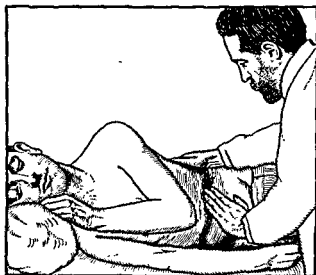


Fig. 43.—Palpation of the spleen

3. Percussion.—

Normal.

Shifting dullness of ascites.

Fluid thrill of ascites.

Hammer percussion over gall bladder, appendix region, and kidneys.

4. Auscultation.—For evidence of intestinal obstruction.

III. METHODS OF EXAMINATION OF THE ABDOMEN

1. Palpation.—

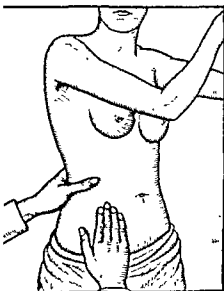
a. To detect inflammation inside the peritoneum. Elicit the twin signs of tenderness on pressure and rigidity of the abdominal muscles over the inflamed organ. The diagnostician should train himself by practice to recognize

rigidity with as much acuity as he does differences of note in percussion of the chest. No accomplishment will reward him more than a delicate and critical ability to determine small degrees of rigidity.

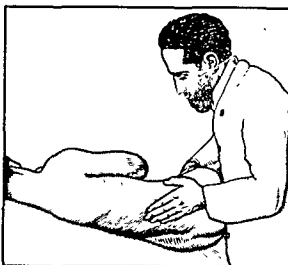
McBurney's point is between an inch and a half and two inches from the anterior spinous process of the ileum on a straight line drawn from that process to the umbilicus. Tender in acute appendicitis.

Mayo Robson's point—"Just as in appendicitis there is tenderness over McBurney's point, in gallstones with very few exceptions, marked tenderness will be found on pressing the finger deeply over the region of the gall bladder or over some point in line from the ninth costal cartilage to the umbilicus."

Murphy's deep grip palpation. Standing directly behind the patient when he is seated on a table, hook the fingers of the right hand deep beneath the right costal arch. Inability to take a deep breath under these circumstances, Dr. Murphy wrote, "is the most characteristic and constant sign of gall bladder hypersensitiveness."



A.

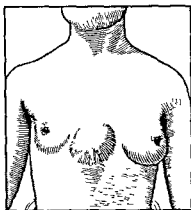


B.

Fig. 46—A, Palpation for nephroptosis. Patient erect. B, Palpation of kidney. Patient recumbent.

To distinguish the difference between intra-abdominal tenderness and tenderness of the abdominal walls, use Carnett's sign. With the patient lying flat have him raise the legs with knees stiff from the table. This tenses the abdominal muscles and protects the underlying organs. If tenderness is present under these circumstances, it must be in the abdominal wall.

b. *Palpation for fluid in the abdomen.*—The tense abdominal wall suggests fluid, or when there are small amounts, a quick bouncing palpation will give a kind of ballottement. To elicit a fluid wave, have an assistant place the ulnar edge of his hand in the midline of the patient's abdomen; with one hand palm down flat against the side of the abdomen, tap lightly on the opposite side, and feel for the wave to reach the palpating palm.



Desmoid of
rectus muscle



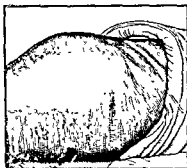
Enlarged spleen
due to leukemia



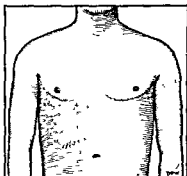
Sarcoma of kidney



Carcinoma of
the pylorus



Cyst of the kidney



Enlarged gall-bladder

Fig. 45.—Abdominal tumors.

c. Palpation of abdominal organs.—

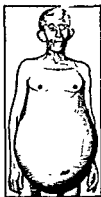
The liver. With the patient lying on his back, he is instructed to let the muscles go loose and to breathe with the mouth open. With the hand flat on the right side of the abdomen, the edge of an enlarged liver can be felt. The normal liver cannot be felt.



Cirrhosis of liver



Pregnancy



Pancreatic cyst



Ovarian cyst



Cardiac ascites



tuberculous peritonitis

Fig. 46.—Ascites and symmetrical enlargement of the abdomen.

The spleen. The cooperative action of both hands are necessary. Standing on the right side of the supine patient, place the left hand over the lower part of the ribs toward the back, and draw the whole splenic region down toward the right hand placed on the abdomen with the fingers at the costal margin.

Tell the patient to take a deep breath. At the end of inspiration, the tip of the spleen should emerge from the ribs and impinge on the finger tips.

To accentuate, the patient may be asked to lie on the right side. Schotter (München. med. Wehnschr., 1929) advised pulling the patient on the right side by grasping his left wrist with the examiner's left hand, at the same time pushing the pelvis back with the right hand. Then, with the examiner's hand placed flat on the patient's belly, and still tugging on the left arm, the spleen is forced down against the palpating hand. "Usually a slight elevation and fall of the hand is enough to reveal the spleen." Middleton's procedure is to have the patient lie on his flexed forearm. This performs the function of displacing the spleen downward and leaves the examiner's two hands free to palpate over the splenic region. (Middleton: Am. J. M. Sc. 167: 118, 1924.)

The Kidneys. Palpation of the kidneys is possible if there is nephroptosis or tumor. The procedure is similar to examination of the spleen—one hand pressing up from behind to thrust the organs toward the palpating fingers of the other hand. The patient should lie on the opposite side. For nephroptosis, the patient should be palpated standing.

d. *Palpation of masses* or tumors in the abdomen: Determine, if possible, what organ is involved; and if the tumor is movable or immovable, soft, doughy, firm or hard, if the surface is smooth, irregular, or nodular, whether it is tender or insensitive.

2. **Percussion of the abdomen** will normally elicit tympany.

When ascites is present, dullness will appear over the fluid, and will shift on shifting position of the patient.

Murphy's first percussion and hammer-stroke percussion were designed to elicit pain and tenderness (not sound). Fist percussion of the kidney is performed with the patient seated in an upright position on a stool and instructed to bend as far forward as possible. "With the patient in this position the examiner, from behind, places his left hand flat upon the back of the patient over the kidney of one side or the other. The clenched right hand of the examiner is then brought down with considerable force on the dorsum of the fixed hand, and if an acute congestion, infarction or retention in the pelvis of the kidney or ureteral obstruction exists in that kidney, the patient will cry out with the pain of the blow."

Hammer-stroke percussion was used by Dr. John B. Murphy to examine an acute condition of the gall bladder. "The examiner, at the right side of the recumbent patient, presses the tip of the second finger of the left hand, flexed at a right angle, firmly up under the costal arch at the tip of the ninth cartilage. The patient is instructed to take a deep breath and at the height of the inspiration, when the gall bladder is forced beneath the costal guard, the flexed finger is struck forcibly with the ulnar side of the open hand of the examiner." (Dowdall, from Professor Murphy's Clin. Arch. Diag., 1910.)

3. **Auscultation.**—The abdomen, like children, should be seen and not heard, except perhaps in acute intestinal obstruction, when at the beginning peristalsis is almost continuous, loud and high pitched. A few hours later peristalsis is still active, but fainter. The musculature of the bowel finally

becomes fatigued and does not respond so strongly to stimuli. Finally all sounds cease. So long as peristaltic sounds are heard, the chance for recovery following operation is good. With some experience the color and condition of the bowel can be predicted by auscultation. If the sounds are active and loud, the bowel is congested, red or pink. If peristalsis is faint and intermittent, the bowel will be purple. If peristalsis is entirely absent, the bowel will be black. (See Stevens: *New England J. Med.* 226: No. 3, Jan. 15, 1942.)

Wangensteen (*The Therapeutic Problem in Bowel Obstruction*, C. C. Thomas, publisher, Springfield, Illinois, 1937):

"Auscultation.—The chief value of auscultation in an acute intestinal lesion relates to the determination of whether *intestinal colic* is absent or present. The repeated audition of borborygmi with the stethoscope at the acme of the pain of which the patient complains establishes the pain as being caused by the intestinal contraction. To be certain, borborygmi or intestinal noises may be heard in other disorders, but it is the intimate time relationship between noise and pain which identifies its origin. A noisy abdomen does not therefore indicate the presence of a mechanical obstruction of the bowel; such a finding only denotes the state of activity of the intestine. A silent abdomen indicates absence of intestinal activity; a noisy abdomen without *intestinal colic* signifies that the bowel is hyperactive."

Excellent references to abdominal auscultation are in Vaughn's section on appendicitis and Ochsner's section on intestinal obstruction in *Nelson's New Loose-Leaf Surgery*.

Tuning Fork Auscultation.—B. B. Vincent Lyon (*Ann. Int. Med.* 18: No. 3, March, 1943) described a method of auscultation of tuning fork vibrations for the detection of adhesions involving the stomach, duodenum, portions of the colon, and gall bladder, and liver. It will not detect adhesions between the omentum and the biliary organs, nor will it detect appendiceal, pelvic, or other abdominal organs. If the bell of a stethoscope is placed over the region of the stomach, and a tuning fork of large size G. sharp, 410 vibrations, is set in vibration and the stem placed also over the gastric region there will be heard a characteristic musical note which Lyon calls the "gastric note." The underlying principle of the test is the conduction or transmission of a tuning fork note from one hollow viscus to another, which is possible only if they are bound together in close relationship, as by adhesions. Thus adhesions between the gall bladder and pylorus are detected by hearing the gastric note continued to the right costal margin. By placing the tuning fork over the region of the liver and keeping the bell of the stethoscope over the stomach region, adhesions between the liver and pylorus or duodenum can be detected.

IV. RELATIVE FREQUENCY OF ABDOMINAL DISEASES

The patient who comes to the office of the general practitioner and who believes that the trouble is localized somewhere in the abdomen constitutes one of a very numerous group. It is impossible to state the relative frequency of the different causes which may be responsible for the symptoms without making some definitions. My definition would demand including such conditions

as pregnancy with vomiting and the enlarged liver of cardiac congestive failure. Obviously when one does that, the digestive diseases and the primary organic abdominal diseases (such, for instance, as the enlarged spleen of leukemia) recede into a decimal minority. We are under the necessity then, of making some distinctions if we are to get such a bird's-eye view.

In the first place, in such a list the functional disorders and the reflex or secondary disorders are overwhelmingly in the majority. By functional I mean nervous dyspepsia. By reflex I mean pregnancy or migraine and by secondary I mean enlargement of the liver in congestive heart failure.

Acute functional abdomen—

Acute digestive upsets—vomiting, nausea, diarrhea, due to bad food, too much food, minor fevers, alcoholism, drugs, early pregnancy, migraine attacks, acute catarrhal jaundice, gastric crises, etc.-----45%

Chronic functional abdomen—

Dyspepsia, constipation, visceroptosis, psychoneurosis, irritable colon, anemia -----25%

Acute organic abdomen -----10%

Acute appendicitis -----4.0%

Cholecystitis, including gallstone colic -----4.0%

Perforated ulcer, gastric or intestinal -----0.2%

Hemorrhage -----0.3%

Intestinal obstruction -----1.0%

Strangulated hernia -----0.5%

Other forms

Fecal impaction -----

Thrombosis mesenteric artery -----

Pneumococic peritonitis -----

Acute pancreatitis -----

} Decimal
Percentage

Chronic organic abdomen -----20%

Enlarged liver from congestive cardiac failure -----6.0%

Peptic ulcer -----5.0%

Pelvic tumors -----2.5%

Cholecystitis -----2.5%

Ascites -----1.0%

Colitis, ulcerative or amebic -----0.5%

Sigmoid diverticulitis -----0.5%

Neoplasm of stomach

Neoplasm of intestines -----

Neoplasm of liver -----

Neoplasm of spleen -----

Neoplasm of kidney -----

} 1%

V. PRESENTING SIGN—GENERAL DISTENTION OF THE ABDOMEN

Ascites is any collection of free fluid within the peritoneum. Free pus is not, however, ordinarily included in the definition. Ascitic fluids are serous, except in the extremely rare instances of chylous ascites.

The four common causes of ascites are:

Cardiac failure with passive congestion of the liver.

Nephritis with renal failure.

Portal and caval obstruction (and in the case of chylous ascites, thoracic duct obstruction)—commonly cirrhosis of the liver, more rarely syphilitic liver; Pick's disease, thrombosis of the portal or caval veins, etc.

Irritation of the peritoneum by inflammation (tuberculosis), or malignant implantation (ovarian cancer), or an enlarged or neoplastic organ (ovarian cyst, splenomegaly, metastatic carcinoma of the liver).

On the basis of the records of over 2,000 autopsies Cabot found that 88 per cent of ascites was due to cardiac weakness, neoplastic peritoneum, renal disease, cirrhosis of the liver, and tuberculous peritonitis in the order named. Clinical records show that cardiac failure as a cause of ascites outnumbers all other causes put together.

The diagnosis of ascites may be either very easy or very difficult. With the large accumulation of cardiac embarrassment or cirrhosis, recognition of the accumulation from the general distention of the abdomen, dullness in the flanks and tympany around the umbilicus in the recumbent position, and fluid wave can hardly be missed. But small accumulations or pocketed accumulations may easily be missed. In these cases one can feel the fluid and hear it gurgle often by putting the forefinger of one hand on the abdomen and jiggling them up and down. Indeed, I have known otherwise accomplished diagnosticians who never get the hang of making the diagnosis of ascites. I remember one instance when a fellow practitioner who had cardiac failure called me in to confirm his belief that he had a pancreatic cyst. I told him he just had plain ascites. He said that could not be because another consultant, one of the best known names in American medicine, said there was no ascites. But the attending physician tapped him and got about a gallon of fluid. Just as we were finished, the owner of one of the best known names in American medicine came in and asked what was going on. When he was told we were tapping the abdomen he exclaimed, "Well, I know you didn't get any fluid."

It is not necessary to dwell at length on the diagnosis of the main form of ascites.

Cirrhosis always produces ascites if the patient lives long enough. It ushers in the stage of decompensation and is the precursor of death.

Syphilis of the liver does not produce ascites as a rule. (See p. 471.)

Ascites in a young subject should suggest first tuberculous peritonitis, and second, Pick's syndrome (adhesive pericarditis, or polyserositis). (See p. 385.)

Chylous ascites most often occurs from carcinoma of the stomach metastasizing into the receptaculum chyli and/or the thoracic duct. In one such case I was able to see and palpate the dilated terminal portion of the thoracic duct above the clavicle. Almost equally common is rupture of the receptaculum by trauma—i.e., the wheels of a car passing over the abdomen. Cirrhosis of the liver has been reported as a cause of thrombosis of the receptaculum. (Medical News, 1905.)

Thrombosis of the inferior vena cava is a rare condition which may occur in the course of carcinoma of the liver, cirrhosis, or, rarely, cholecystitis. There

is invariably ascites, and usually edema of the lower extremities. The collateral circulation is usually established in deep branches so that superficial veins are not in evidence.

Chiari's syndrome (Chiari: Beitr. z. path. Anat. u. z. allg. Path. 26: 1, 1899) is obliteration of the hepatic veins due to thrombophlebitis. It may be due to a variety of lesions situated at the junction of the hepatic veins and the inferior vena cava—neoplasm, gumma, cirrhosis of the liver (Hutchinson and Simpson: Arch. Dis. Childhood 5: 167, 1930), inflammatory masses, hypernephroma (Jacobson and Goodpasture: Arch. Int. Med. 22: 86, 1918), and polycythemia vera (Altschule and White: New England J. Med. 22: No. 25, June 22, 1939). In one group of patients the onset is gradual with, after a period of premonitory epigastric pain, ascites, a large tender liver, and dilatation of the superficial veins of the chest and abdomen. Vomiting is common; jaundice is not. Death is inevitable in one to six months. In the group with sudden onset and the course fulminating with coma and delirium, there is rapid development of the signs enumerated and death occurs within a week or less.

Differential diagnosis of ascites must be made from ovarian cyst, pregnant uterus, distended bladder, pancreatic cyst, echinococcus cyst. The contiguous circumstances and etiologic factors enter into the judgment more than the physical examination of the abdomen. Examination of the peritoneal exudate as described by Steinberg (J. A. M. A. 11: No. 7, Feb. 15, 1941) may give some help.

Distention of the abdomen, the result of tumors such as the enlarged spleen of leucemia, the pregnant uterus, ovarian cyst or pancreatic cyst, should cause the diagnostician no difficulty.

Hirschsprung's disease, megacolon, is a rare but almost the only cause of distention. Strictly speaking, Hirschsprung's disease is an idiopathic congenital dilatation of the colon. Perthes said that when a definite mechanical reason can be found for the disease, it precludes its being classified as Hirschsprung's disease. But in so many cases kinks are found at the splenic flexure or the descending colon, or at the rectosigmoid juncture, that rigid classifications of this kind are not practical.

The sigmoid especially, but also the whole colon, is enormous. In Formad's case the circumference of the colon was from fifteen to thirty inches and the weight of the contents forty-seven pounds (Osler). The taeniae and haustra are almost erased. The wall of the gut is thin.

The symptoms usually begin during the first month of life, but may be delayed until the end of the first year or more.

The two characteristic signs are distention of the abdomen and obstinate constipation. In many cases the cause of the distention can be seen to be the dilated colon, the coils of which can be discerned through the abdominal wall. Visible peristalsis is seen in some cases, and sometimes in most cases, depending upon the stage of activity of the colonic musculature. The constipation is severe, days and often weeks passing without a bowel movement. Rectal examination may detect an obstruction or kink, perhaps the fons et origo of the condition.

Megacolon in adult life is, I believe, always the end-stage of Hirschsprung's disease in infancy. The patients have distention, which is likely to come in spells or attacks, and constipation and also a steatorrhea and a general constitutional condition which has been called "nontropical sprue." There is anemia, achlorhydria, indigestion, disturbance of pancreatic physiology, low blood sugar curve, weakness, and underweight. (See Hanes and MacBryde: Identity of Tropical Sprue, Nontropical Sprue and Celiac Disease, Arch. Int. Med. 58: 1, 1936.)

Von Gierke's disease is a glycogen storage disease, perhaps related to Gaucher's disease. It is congenital, probably a Mendelian recessive character. It begins to present in infancy or early childhood as a distended abdomen due to an enlarged liver, three or four times normal, and an enlarged heart, possibly enlarged kidneys. All the enlargements are due to glycogen deposits which may appear also in the skeletal muscles, and give the cells a vacuolated appearance. The spleen is not enlarged. Growth retardation in youth and obesity are common. Blood sugar is low and blood cholesterol increased. Periodical vomiting is common; jaundice does occur.

Phantom Tumors.—Nearly every practitioner of long experience has a story about a puzzling abdominal tumor, which disappeared when laparotomy was made, or under an anesthetic. Speculations as to their nature have varied. Sir James Paget, in *Clinical Lectures and Essays* (1875), has quite a long chapter on them. He believed the tumor to be due to the swelling of part of a muscle during contraction. The abdomen is, I suppose, the commonest site of these phantoms. Sir James relates the history of a patient, a woman of thirty, with a tumor in the upper part of her abdomen. "It was roundish, firm, nearly hard, constant in its characters and place, often painful and distinctly pulsating, like an aneurysm. In full medical and surgical consultations with my colleagues, the question was whether it was a tumor with a pulsation communicated from the aorta, or aneurysm. The opinions were many, and various, perhaps because the tumor was painful. So one day I gave the patient chloroform and the tumor, the aneurysm, and the doubt disappeared: they were all phantoms."

VI. PRESENTING SIGNS—RIGIDITY AND TENDERNESS OF THE ABDOMEN

The typical acute abdomen has a sudden, stormy onset with pain, fever, nausea, vomiting, rigidity, tenderness, later distention, shock, and collapse. If due to inflammatory processes leucocytosis must be added to this.

The causes of the acute abdomen are, in order of frequency: acute appendicitis, acute cholecystitis, salpingitis, perforated peptic ulcer, pre-eruptive herpes zoster, acute intestinal obstruction, strangulated hernia, twisted ovarian pedicle, ectopic pregnancy, gastric crisis of tabes, acute pancreatitis, mesenteric thrombosis, Meckel's diverticulitis, and acute yellow atrophy of the liver. Acute appendicitis is numerically more frequent than all the rest put together.

One of the primary obligations for every practicing physician is the ability to recognize the acute abdomen as soon as he sees it. He must then run over in his mind the list of causes and strive to make a differential diagnosis.

Acute Appendicitis.—(See below.)

Intestinal Obstruction.—The causes of acute mechanical obstruction are, in order of frequency: strangulated hernia, volvulus from the intestine twisting about a postoperative adhesion to the anterior abdominal wall, intussusception, sigmoid volvulus, intussusception or volvulus of Meckel's diverticulum.

Midway between acute and chronic obstruction are the sudden onset of acute obstruction from tumor of the bowel (due to swelling or hemorrhage into the tumor), fecal impaction, and obstruction due to packed ascaris lumbricoides (Venning: Intestinal Obstruction Due to Ascaris Lumbricoides, J. A. M. A. 54: No. 25, June 18, 1910).

Volvulus of the intestine around a postoperative adhesion has, in this century of surgery, acquired second place after appendicitis, as a cause of acute abdomen. The usual pathologic picture is a thin strand of adhesion, an inch or more long, attached to the peritoneal site of an old laparotomy scar at one end and the intestine at the other. It usually occurs in the small intestine and hence vomiting comes on early and is the dominant symptom. Pain is intense, but distention not marked, and tenderness and rigidity are likely to be localized in the upper half of the abdomen.

Meckel's diverticulum is a pouch from the small intestine, the vestigial remains of the omphalomesenteric duct. It persists in from 1 to 2 per cent of all individuals, according to different reports. It is much more frequent in males. It may only be a small unattached knoblike projection, but in 161 cases with pathologic changes it was attached to the umbilicus in 110 cases (Turner: Guy's Hosp. 9: 279, 1906). It may be attached to nearly any portion of the small intestine between the last third of the jejunum and the last third of the ileum, although usually it arises from the ileum about two feet from the ileocecal valve. Of extreme rarity is an umbilical fistula.

Lesions due to Meckel's diverticulum seem oftenest to produce symptoms in adult life, the average age of Porter's patients being 21 years, 9 months. (Porter: Abdominal Crises by Meckel's Diverticulum, J. A. M. A. Sept. 23, 1905.)

Meckel's diverticulitis may have a long recurrent history. In infants there is indigestion, fever, vomiting, constipation, followed by several soft, bloody stools. It can occur at any age, but the majority of attacks occur after childhood. One-third of a reported series were children, nearly a half were 20 to 54 years. Cases have been reported at the age of 70 and over. Fecal concretion lodging in the diverticulum may initiate the attack. It is the most frequent disease of Meckel's diverticulum.

Obstruction from Meckel's diverticulum occurs most frequently as strangulation by the constricting band, the ileum becoming ensnared (101 of Porter's 184 cases were of this nature). The average age of onset is 15 years. Intussusception is next in frequency, these always being, of course, in the free variety

(20 of Porter's cases), and volvulus by the intestine twisting about the stalk (8 of Porter's cases). The average age of onset in all cases of Meckel's obstruction is 13 years.

Paralytic ileus is intestinal obstruction not mechanical in origin, but due to paralysis of the musculature of the bowel. It occurs as a complication of laparotomy or as the terminal event in peritonitis.

Mesenteric thrombosis of the arteries from endocarditis, emboli from any source as mitral stenosis, or arteriosclerosis, causes local gangrene of the bowel with the symptoms of obstruction. It is usually fatal.

Torsion of the pedicle of an ovarian tumor may come on gradually, or suddenly. If gradually it may cause only moderate distress. If sudden it causes acute agonizing pain, rigidity, and tenderness with symptoms of shock, the whole picture simulating acute peritonitis.

Ectopic pregnancy constitutes an abdominal emergency of great importance. It stands high among the causes of maternal mortality. The anatomic forms are varied: there are reports of twin ectopic pregnancy, and concomitant uterine and tubal pregnancy. The interstitial form in which the fetus develops in the tube just at its entrance to the uterus, actually in the wall of the uterus, may not rupture until the fourth or fifth month. In the usual isthmie, or ampullary, location, in the tube itself, rupture and tubal abortion occur at the second or third month.

Diagnosis of interstitial ectopic pregnancy before rupture is very difficult. There is a history of a skipped period, or the flow has not lasted more than a day. In every respect both in history and by vaginal examination, the signs may be those of intrauterine pregnancy.

After tubal abortion, or rupture, the clinical picture is quite characteristic. There is a history of early pregnancy, interrupted by an attack of sudden pain in the pelvic region, fainting, a discharge of blood from the vagina, followed by symptoms of shock, or rather hemorrhage.

Less abrupt onset produces a succession of cramplike pains and a bloody vaginal show, not enough to call a hemorrhage.

In all cases the signs of internal hemorrhage begin to appear—pallor, dizziness, rapid pulse, deep sighing breaths. A bluish discoloration around the navel is a reliable sign of intra-abdominal accumulation of blood.

Fever is not marked. In 150 cases Farrar never found the temperature above 101.5° before operation.

Leucocytosis is a regular finding and often the height of the leucocyte count indicates the degree of activity of hemorrhage.

Vaginal examination shows a uterus usually somewhat enlarged, almost like the uterus of the stage of gestation that is present. In the region of the ruptured tube is a boggy, non-sensitive, sausage-shaped, or ill-defined mass. If it floats anteriorly the indication is strong for ectopic and against salpingitis.

Tubal pregnancy is more often overlooked and more often diagnosed when not present than any other pelvic disease.

Strangulated inguinal hernia does not often constitute a diagnostic problem. The patient usually announces the diagnosis, although not always, and in the presence of intestinal obstruction it should always be eliminated or confirmed as the first procedure. The diagnosis is made: (1) a hernia formerly reducible is now irreducible; (2) a tumor, or mass, in the inguinal region, or scrotum, nonexpansile on cough, and tender; (3) a feeble, rapid pulse; (4) an anxious facial expression; (5) a slightly distended abdomen tender at the navel epigastrium and vicinity of rupture; (6) nausea and vomiting; (7) fever and leucocytosis late.

Peritonitis.—Generalized acute peritonitis may be the first indication the clinician has of a peptic ulcer, an appendicitis, a salpingitis, an intestinal obstruction, or a puerperal sepsis. Many a duodenal ulcer is silent until it perforates. Hertzler (*Surgical Pathology of the Peritoneum*, J. B. Lippincott, 1935) divides peritonitis into the hyperemic, the exudative, and the plastic stages. The clinician should recognize it in the hyperemic stage, if his therapeutic efforts are to be rewarded. The initial sign of any perforation of the bowel is pain followed by a period of calm. This is true of perforation of a duodenal as well as of a typhoid or colon ulcer. In about 50 per cent of cases the pain is severe enough to cause the summoning of medical council. That is the golden time to make the diagnosis. After the period of calm the signs are rising temperature, rigidity, tenderness, leucocytosis, vomiting, distention, and shock. They represent, progressively, periods of increasing danger and calamity.

Pneumococcic peritonitis occurs almost entirely in children and in 75 per cent of cases in females in whom the portal of entry is the uterosalpingo canal. It may be primary or secondary. The secondary cases follow pneumonia or a respiratory infection, a point of importance in diagnosis. Otitis media is also a precursor. The symptoms are the same as of general peritonitis of any kind—pain, vomiting, fever, thirst, hiccup, leucocytosis, tenderness, rigidity, and distention. Diarrhea is mentioned by all authors, although in ordinary general peritonitis diarrhea is not common. The mortality is about 85 per cent even with modern chemotherapy.

Acute yellow atrophy of the liver occurred three times in 28,000 cases admitted to the Johns Hopkins Hospital during 23 years. The symptoms are acute and fulminating, with rapidly developing jaundice, vomiting, shock, and prostration. Some cases have been reported in which the onset was less abrupt, with prodromal headaches and gradually developing jaundice over a two or three weeks' period. The liver is found to be extremely small with extensive necrosis of parenchymal cells. The duration of the disease has been reported as long as forty days. It is highly fatal; if recovery does occur the liver undergoes cirrhosis.

The etiology is varied, leading to the saying that it is a symptom-complex rather than a disease. The factors listed are pregnancy (about half the cases), alcohol, phosphorus, chloroform, infectious jaundice, and syphilis. However, in my small experience, cases occur for which no etiologic agent can be identified. Most cases occur from the tenth to the fortieth year. Rolleston collected 42 cases occurring before the tenth year.

VII. PRESENTING SIGN—ABDOMINAL HEMORRHAGE

Vomiting of blood in over 90 per cent of cases is due to peptic ulcer or gastric cancer. Cirrhosis of the liver is the next thing to think of, and in the presence of enlarged spleen, Banti's disease or hemolytic anemia. Rare, puzzling instances occur in association with intra-abdominal infection (appendicitis, etc.) probably due to infective emboli carried to the gastric mucosa, and a few scattered reports of hematemesis in association with bacterial endocarditis (petechiae) are found in the literature.

Bleeding from the bowel occurs from any ulcerative lesion of the gastrointestinal tract, including ulceration of neoplasms and varices. Tarry stools indicate upper digestive tract lesions. Hemorrhoids and rectal ulceration produce fresh blood.

Henoch's purpura (Henoch: *Klin. Wehnschr.* 11: 641, 1874) consists of purpura of the skin, arthralgias, stiff joints, possibly arthritis joint pains, with visceral symptoms, such as nausea, vomiting, abdominal cramps, diarrhea, and bloody stools. First described in children it occurs, however, in those of all ages. It is probably allergic, many of the individuals showing food sensitivity.

Concealed internal hemorrhage, especially from ulcer, produces a syndrome which unfortunately seems not to be very well known in the profession at large, as witness the remarkable narrative of Irvin Cobb—"How It Feels to Die."

Mr. Cobb relates that he was making a lecture tour through the larger cities of the United States and every evening as he was dressing for his appearance on the stage he would be overcome with faintness and lie on the bed for a while. He moved daily from city to city. It is worth noting that in every city he consulted a physician: presumably he obtained the best, or at least better than average, medical consultation. Every physician examined his heart and reassured him. Not one took a blood count or even a hemoglobin estimate. Finally, at his last stop, he lay down on the bed and when he came to he was undressed, under the covers, and in the room were his manager, a doctor, and a nurse. The doctor was estimating his hemoglobin on a Tallquist scale, and found it 40. Incidentally, Mr. Cobb had been having indigestion and there was a bottle of sodium bicarbonate on his dresser. He then went through a series of sensations which give point to the title, "How It Feels to Die." He writes that he felt like a sphere floating on the surface of the ocean, and then he began to sink; he went through depth after depth of colder, darker water and then very gently hit the bottom. Then he bounced and began to rise through even warmer and lighter strata until he came to the surface and then he took a long breath. This experience was repeated until one time he hit the bottom and did not bounce, and then the lights went out. Whether that is how it feels to die no one knows, but it certainly is the syndrome of internal hemorrhage.

VIII. PRESENTING SIGN—LOCALIZED TUMOR, OR RIGIDITY, OR TENDERNESS

A. Upper Left Quadrant of the Abdomen

MECHANICAL DERANGEMENTS.—Diaphragmatic hernia is the only true mechanical derangement of the upper left quadrant and except when a large spontaneous herniation of a considerable part of the abdominal viscera occurs into the thorax, there are no physical signs: the diagnosis, if made at all, must be suspected from the history and the final diagnosis by x-ray.

Inflammations.—We will include peptic ulcer under this heading. Moynihan, who is largely responsible for formulating the symptom-complex by which we recognize ulcer (see p. 97), wrote, "the anamnesis is everything: the physical examination nothing." Sometimes it is possible to delimit a definite area of tenderness. There may be some rigidity of the upper left rectus. If induration is considerable, a small tumor may be felt. If perforation has occurred and the opening has been closed with omentum and there has been some localized peritonitis, a mass more or less indefinite can be made out. With obstruction visible, peristalsis can be seen. But these are rarities: in well over 90 per cent of cases the physical examination in ulcer is completely negative.

Syphilis of the stomach appears in the form of ulcer or of gumma. Warthin (Am. J. Syph. 2: 425, 1918) described a diffuse form of infiltration. Forms similar to linitis plastica occur. Most cases initiate carcinoma, but it is a very rare condition, appearing once in about 15,000 consecutive medical cases. The clinical course is rapid and severe. Pain, vomiting, great weight loss, emaciation, secondary anemia of high grade, and a palpable mass are the findings. Suspicion may be aroused when symptoms that appear to be an ordinary ulcer do not respond to alkaline therapy. The x-ray plate shows a stomach of diminished capacity (See Eusterman: J. A. M. A. 96: No. 3, Jan. 17, 1931).

Tenderness and pain and rigidity in the abdominal and lumbar region may mean kidney stone or infection. The procedure of Murphy, namely, fist percussion over the lumbar region, is useful. It reminds one of the famous test for kidney stone of Mr. Cameron, of Toronto. He had the patient stand on a chair and then told him to leap down. If the patient did so, he had no kidney stone. If he told the doctor to go to hell and clambered down slowly, he did.

A history of recent infection of the skin (crops of furuncles or even a single furuncle, a carbuncle, an erysipelas) followed by pain in the lumbar region should always make the diagnostician pause. It suggests perinephric abscess first and Brewer's kidney second. Many surgeons, even urologists, state that perinephric abscess is always secondary to renal infection—tuberculosis, for instance. This simply means they have never recognized the entity. Most patients go to a general practitioner with a diagnosis of lumbago. The abscess is entirely outside the kidney in the perirenal space. It is true

that in many instances, perhaps all, the primary metastatic abscess was in the renal cortex and ruptured into the perigenal space. But the cortical focus heals and plays no part in the process. I have seen a few autopsy specimens and a few that some thorough surgeon decided to remove, and in the kidney there was not a spot to indicate that the abscess was primary there: Why they should metastasize from the skin is a mystery. The signs of pain, rigidity, a hazy tender mass with leucocytosis and clear urine should suggest the condition. Eighty per cent are on the right side.

Brewer's kidney is a clinical entity which should be included in all accounts of the acute abdomen. It consists of infective emboli into the kidney substance which practically never go on to suppuration. The original focus of infection may be anywhere in the skin, but in most cases it is never found. The signs are chill, temperature of 101° F., leucocytosis, pain in the lumbar region—all coming on suddenly. Tenderness over the kidney may be exquisite. Most cases are on the right side. Urinary changes do not appear until later when albumin, pus cells, bacteria, and blood in small amounts may be found. The condition resembles acute abdominal crises of other nature—notably appendicitis.

Tumors of the upper left quadrant are carcinoma of the stomach, lymphoma of the stomach, various other tumors of the stomach, carcinoma of the splenic flexure of the colon, other tumors of the colon, enlargement of the spleen, floating kidney, enlarged kidney, adrenal tumor, tumor of undescended testis, retroperitoneal tumors, and aneurysm of the abdominal aorta.

The old idea that if a carcinoma of the stomach can be palpated, it is too late for surgical treatment, is not wholly true. Indeed, some of the most easily palpated are circumscribed and easy of resection. About 60 per cent of gastric cancers present a palpable tumor early or fairly early in the course of the disease. Visible peristalsis is present when the tumor obstructs the pylorus in about 80 per cent of such cases. If not present, it can be stirred up by flapping and paddling the abdominal wall. Very important for the clinician after the tumor itself has been detected is to examine the favorite locations for metastases—Virchow's node just above the clavicle, the liver, the umbilicus, spleen, and colon. Pulmonary metastases are uncommon. Implantation in the rectal pouch, the rectal shelf of Blumer, should be investigated. The *Krukenberg* tumor, in which the peritoneum and both ovaries are involved, occurs in 5 per cent of cases.

In infants, the palpation of a hard small tumor in the epigastrium or upper abdominal segment confirms the diagnosis of hypertrophic pyloric stenosis.

Lymphoma has been stressed by Means (*The Symptology of Lymphoma; Its Endless Variety*, J. A. M. A. 113: No. 8, Aug. 19, 1939). The term includes lymphoblastoma, reticulum cell sarcoma, lymphosarcoma, Hodgkin's disease, and giant follicular lymphoma. The common type for clinical purposes is a lymphatic tumor without blood changes, and radiosensitive. The tumors may arise from any lymphatic tissue, but most probably begin in a lymph follicle in the submucosa. Symptomatically it can imitate many things—peptic ulcer,

acute appendicitis, small bowel obstruction, ulcerative colitis and, although they do not concern us here, pulmonary tuberculosis and polyarthritis. Regional ileitis is strongly suggestive of this condition. A palpable abdominal tumor is frequently present.

There are a number of tumors which may occur in the stomach—sarcoma, myoma, fibroma, lipoma, neurofibroma, and dermoid cysts. They have little clinical significance except as the finding of a tumor is an indication for exploratory laparotomy. The exact diagnosis is seldom made except by biopsy or at autopsy.

Carcinoma of the Colon.—White (Am. J. M.Sc. 186: No. 5, Nov., 1933) in a study of 53 cases of carcinoma of the colon had 7 located at the splenic flexure, 5 in the transverse colon, and 4 of the descending colon. Acute obstruction occurs in these tumors near the splenic flexure more often than with carcinoma elsewhere in the bowel except at the cecum. Chronic obstruction also occurs. The signs of carcinoma of the colon in order of frequency are indigestion, weight loss, constipation (more frequent in lesions of the left side than of the right side), blood in the stool, secondary anemia, and obstruction. Alternating diarrhea and constipation are more frequent in textbooks than in practice. Diarrhea in growths above the rectum is an almost negligible symptom.

Palpable Spleen.—Small palpable spleen is almost always due to malaria, sepsis, undulant fever (typhoid no longer is a frequent factor), infectious mononucleosis (50 per cent of cases), or other infection, pernicious anemia or secondary cirrhosis of the liver. Myelogenous leucemia, Banti's disease, splenic anemia, hemolytic jaundice, Hodgkin's disease are the common causes of very large or moderately large spleens. Gaucher's disease causes large spleen, but is very rare. Gaucher's disease (Gaucher: "These de Paris, III. 3-31, 1882) begins almost always in childhood and infancy, often affects several members of a family of the same generation, and is characterized by progressive enlargement of the spleen, to enormous size, and subsequent enlargement of the liver. A characteristic brownish-yellow discoloration of the skin on the exposed parts of the body, and a peculiar yellowish, wedge-shaped thickening of the conjunctivae of both sides of the cornea are seen. There is an anemia and a moderate leucocytosis. Thrombocytopenia is a marked and early picture. It has a predilection for the Jewish race. The cells of the spleen, liver, bone marrow and elsewhere were called epithelioma by Gaucher and endothelioma later, but are quite *sui generis* and contain lipid granules, identified as keratin.

Niemann-Pick's disease is similar to Gaucher's, but observed only in infancy. There is general lymph node enlargement. Enlargement of the liver occurs early. In the spleen, bone marrow, and monocytes of the peripheral blood there are large vacuoles, lipid in reaction.

Neoplasms of the spleen are rare, sarcoma accounting for over 95 per cent of them. Felty's syndrome (Bull. Johns Hopkins Hosp. 35:16, 1924), consisting of enlargement of the spleen, leucopenia and arthritis in elderly persons, is believed by Price and Schoenfeld (Ann. Int. Med. 7: No. 10, April, 1934) to be due to chronic infection.

Thrombosis of the splenic vein produces agonizing pain in the left upper quadrant, with a rapidly enlarging spleen and usually ascites. The liver is usually not enlarged.

Cysts of the spleen are rare. They produce large, easily palpable tumor, with usually no symptoms. The true cysts have a lining membrane and are apparently neoplastic. They can usually be detected on x-ray examination. When calcified, such identification is easy. The only two conditions showing calcification on the x-ray plate in the upper left quadrant are calcified splenic artery and calcified splenic cyst (Sweet: *New England M. Jour.* 228: No. 22, June 3, 1943).

Banti's disease, splenic anemia. Banti (Beitr. z. path. Anat. u. z. allg. Path. 24: 21, 1898) described an anemia with enlarged spleen and cirrhosis of the liver and Osler named it Banti's disease (*Am. J. M. Sc.* 119: 54, 1900). Since then a great deal of critical analysis of the cases has occurred, and it is often said that no such disease exists. The criticism is largely along the line that sections of the spleen in Banti's disease cannot be differentiated from the spleens of hepatic cirrhosis. Undoubtedly, the histology of Banti's spleen is not specific and undoubtedly, many cases of hemolytic anemia, and myelogenous leucemia without leucocytosis have been called Banti's, but I believe that cases of Banti's syndrome occur and do not fit into any other clinical picture.

The age of onset is under thirty-five years. The onset may be insidious, but in all of my cases it began with copious vomiting of blood. In fact, most of the anemia can be ascribed to the hemorrhage. The spleen is easily palpable, but never attains the size of a leucemia spleen. The liver is palpable in about half the cases. The average red cell count is 3,000,000. The red cells are normocytes. A leucopenia affecting all types of white cells is a regular part of the picture. The course of the disease may be long and benign, although liable to interruption by gastric hemorrhage.

Schistosoma Japonica (Bilharziasis, Blood fluke disease).—The form which is endemic in the Far East—China, Japan, Formosa—produces splenomegaly and ascites. (Meleney: *Med. Clin. North America* 27: No. 3, May, 1943.)

Histoplasmosis of Darling, a rare infectious disease caused by the fungus *Histoplasma capsulatum*, has been reported in the United States. In the reticulo-endothelial cells in the body tissues and in the monocytes in the blood the parasites resembling yeast in structure are found: they can be cultivated. The prominent signs are splenomegaly and hepatomegaly. The onset is with fever, vague abdominal pain, diarrhea, and acute bronchitis. Death has always occurred. (Humphrey, A. A.: *Reticulo-endothelial Cytomycosis* [Histoplasmosis of Darling], *Arch. Int. Med.* 65: 902, 1940.)

Hemartoma of the Spleen (Splenoma) is a tumor composed of tissue, present in excess beyond normal requirements, that can hardly be distinguished from normal but possesses a limited capacity for aberrant growth. They are benign and often attain a large size. The tumor is probably of embryonic or embryonic rest origin. In Fischer's case the spleen weighed 2,100 grams. The only symptoms or signs are of splenic enlargement, the function of the spleen

not being disturbed. The age of onset of growth of the organ has varied in the reported cases from twenty-eight to eighty-four years. (See Sweet and Warren: *England J. Med.* 226: No. 19, May 7, 1942.)

Abscess of the spleen should always be kept in mind as a possibility when in the course of even minor suppuration elsewhere the spleen enlarges, with tenderness and pain. Furunculosis, otitis media, erysipelas, femoral thrombophlebitis, and appendicitis have been the etiologic foci in reported cases. The metastatic splenic symptoms may develop from one day to several months after the original suppuration. There may be symptoms and signs of left abdominal disease without palpable spleen, and the abscess may be deep in the splenic tissue, producing chills and fever and palpable spleen without pain or tenderness. (See Wolfson: *New England J. Med.* 230: 135, Feb. 3, 1944.)

Thrombosis of the portal system, especially the portal vein, produces splenomegaly and ascites of quite sudden onset. It may be a complication of portal cirrhosis of the liver, but cases are on record of spontaneous occurrence in apparently previously healthy young individuals. (See Reich: *Ann. Int. Med.* 7: No. 2, Aug., 1942; and Bissell: *Med. Clin. North America* about 1920-1925.)

Palpable Kidney.—(This discussion applies equally to the right side.)

With a patient's history of Dietl's crisis it is significant if you can feel the lower pole of the kidney with the patient standing. Usually, however, with Dietl's crisis one can push the kidney over most of the abdomen.

Kidney tumor may be due to hypernephroma, sarcoma, cystic kidney, adenocarcinoma, tuberculosis, hydronephrosis, pyelonephrosis.

The old diagnostic homilies about differentiating a splenic from a renal tumor by the fact that the colon is in front of a renal and behind a splenic tumor never made much sense: in the only cases in my experience where there was any confusion the colon was completely displaced anyway. And modern urologic diagnostic methods have made kidney tumor diagnosis so exact that it is taken out of the internist's hands. All the internist is supposed to do, therefore, is to decide that a given tumor is renal in nature and turn it over for a careful urologic work up.

Undescended Testis.—The finding of an undescended testis with an abdominal tumor is a matter of great significance to which Osler called attention but which has been entirely neglected by most diagnosticians and textbook writers since. The tumor may be anywhere in the body, but is most likely to be in the kidney region; most of them are on the left side. They are cystic in nature, probably dermoids. In one such case reported by Outland and myself (*Surg., Gynec., and Obst.* 22: 204, 1916), the patient was 62 years old and had carried the tumor for 15 years. It was the size of a small watermelon, occupied the left side of the abdomen, and was filled with a thin chocolate-colored fluid.

Retroperitoneal tumors may occur anywhere. In a series of 45 cases, 9 occurred in the upper left abdomen or in the epigastrium. They may be malignant or benign. They are lipoma, fibroma, myxoma, chondroma, myoma, neuroma, sarcoma, lymphadenoma, mixed, and of all varieties of cysts. The

age incidence is preponderantly from thirty to seventy. The symptoms are dependent on location. An abdominal mass presented in most cases, and also abdominal pain. When the growth is in the lower abdomen or pelvis it usually invades nerve tissue or vertebrae and produces pain in the legs, back, bladder, testicle, leg paresthesias, etc

Tumors of the small intestine may occur anywhere. The benign tumors are adenoma, lipoma, fibroma, myoma, angioma, cysts, lymphangiectasis, and multiple cavernous hemangioma. Of the malignant growths both carcinoma and sarcoma occur, sarcoma being much more frequent in the small intestine than in the large. The symptoms will depend on the location and degree of obstruction. The higher up in the gut the tumor, the more likely symptoms are to be pronounced. Extraordinarily large tumors are usually sarcoma and are quite painless. (Haggard: *Tumors of the Small Intestine*, J. A. M. A. 59: No. 4, July 27, 1912.)

Situs inversus may produce quite startling dullness and even solid tumor from congestive heart failure, in the liver in the left upper quadrant. The latter happened to me once in a 65-year-old man who had never suspected his condition. (Pasternack: *New England J. Med.* 227: No. 25, Dec. 17, 1942.)

B. Upper Right Quadrant of the Abdomen

Aside from duodenal dilatation and duodenal ileus (see Wilkie: *Am. J. M. Sc.* 173: 643, 1923) the only mechanical derangement of the upper right quadrant is gallstones, and these will be considered as terminal results of inflammation.

Cholecystitis is one of the commonest diseases in human beings over the age of forty. This is not difficult to understand because the portal circulation is constantly carrying toxins and bacteria from the entire bowel to the liver for detoxification and elimination, and the bile is the only route for such elimination. The gall bladder is the main site where stasis occurs; on its walls and in the bile flow, therefore, the bacteria and toxins would naturally do their work. Pregnancy also, for some reason, affects the gall bladder. Mann and Higgins found that the normal emptying of a gall bladder when a fat meal is given does not occur during pregnancy. This observation was repeated in the dog, the guinea pig, and the gopher. When the uterus is emptied the gall bladder resumes its normal response to the emptying reflex. Pregnancy and gallstones have long been linked by clinicians.

The succession of changes which may go on in the gall bladder is of a great variety. Theoretically the order of the process should be acute catarrhal cholecystitis which either subsides or progresses into chronic cholecystitis which goes on to the formation of gallstones, which then may or may not set up mechanical disturbances leading to indigestion, colic, impaction in the cystic duct, invasion of the common duct with jaundice. Practically, this happens often enough, but there are variations. The acute cholecystitis may lead to suppuration with empyema of the gall bladder. The stone impacted in the cystic duct may lead to hydrops or mucocele of the gall bladder. In such cases

the walls of the gall bladder are very thick and reticulated. Indeed, the cystic duct can be obliterated by chronic inflammatory processes alone, with no gallstones to be found.

A variation of such processes is a metabolic form of inflammation of the gall bladder. The mucosa is roughened, resembling the surface of a strawberry. The process is due to the deposit in the villae of cholesterol-like deposits. Infection also plays some part in the process. Whether these gall bladders go on to stone formations, as I understand it, is not entirely certain.

Another, though rare, event which may arise as a complication in this process of inflammation and stone formation is rupture of the gall bladder. In a series of 6,800 cases of gall bladder disease, perforation occurred 96 times. (Eliason and McLaughlin: *Am. Surg.* 99: 914, 1934.) Perforation occurs with and without stones: in the proportion of about 3 to 1. The mortality is about 5 per cent (Stone and Douglas: *Am. J. Surg.* 45: No. 2, Aug., 1939). The history nearly always shows a more or less long period of chronic cholecystitis. The symptoms of onset are pain, vomiting, chills, fever of not very high degree, and moderate leucocytosis. The signs are tenderness and rigidity and a feeling of a tender mass in the upper quadrant.

The diagnosis of these conditions depends upon a knowledge of the various forms of pathology which may occur. Long ago Moynihan taught us to abandon the idea that the signs of gallstones are colic, vomiting, and jaundice. A very large number of cases of chronic indigestion are due to cholecystitis or gallstones. When the inflamed gall bladder rests on the duodenum and especially when it becomes adherent there, the most exact and exquisite imitation of duodenal ulcer will ensue. But any chronic indigestion with discomfort after meals, anorexia, nausea, and meteorism with belching, which is an especial sign of gall bladder indigestion, should be suggestive. The elicitation of rigidity and tenderness with the maneuvers of Murphy (see p. 96) are signs more likely to be present than any found in ulcer. The use of cholecystography has given us the most reliable objective sign of gall bladder disease.

The diagnosis of acute gallstone colic with sudden onset, fairly sharp localization over the gall bladder, and radiation around the costal border and into the right shoulder is not usually difficult.

Stone in the common duct may pass on through into the duodenum, making its passage by colic, vomiting, and jaundice or it may lodge in the common duct giving rise to a syndrome of more or less classical outlines. The attacks are intermittent, marked by the hepatic fever of Charcot, colicky pain, transitory jaundice, chill, sweating with otherwise negative physical findings. In quite a proportion of cases these attacks come on after a gall bladder operation in which a large number of stones have been triumphantly removed. Either a stone in the common duct has been overlooked or one has come down from the liver, or a new stone has formed. Gallstones certainly form with remarkable rapidity. Cameron (*J. A. M. A.* 81: No. 20, Nov. 17, 1923) reported a case where thirty-eight gallstones, all of considerable size and lamellated, formed within eighty-six days.

It must not be supposed that stone in the common duct always produced the classical picture of chill, intermittent jaundice, etc. They may occur without any trace of jaundice. Most of the cases of so-called postoperative biliary dyskinesia are really stones in the common duct.

The gall bladder as a tumor is a not infrequent occurrence. Mostly, of course, it occurs with mucocele or hydrops of the gall bladder, but at times it may be so large as to be puzzling.

Acute pancreatitis is a chemical form of inflammation. It occurs when the pancreatic duct is occluded and secretions are dammed back, causing autolysis. In 78 per cent of cases the cause of the obstruction is a gallstone which has moved down the common duct into the ampula of Vater. Other cases are not so easily explained. They frequently occur after a heavy meal. The symptoms and signs are those of acute abdomen. It is, however, far more acute, fulminating, and severe than any other form of acute abdomen. The initial pain is agonizing, the toxemia profound, and shock and ileus follow very rapidly. There is tenderness over the pancreas and rigidity. There is an elevation of serum amylase. The correct diagnosis is seldom made, the most common mistake being to label it perforation of a duodenal ulcer. The mortality, by conservative treatment, is about 22 per cent, from 50 to 75 per cent when operation is performed.

Chronic pancreatitis is an increase in the connective tissue of the organ. It may follow an acute pancreatitis. It is usually associated with chronic gall bladder disease or arteriosclerosis. The diagnosis is almost never made during life, except on suspicion. Vague digestive distress, bloating, belching, attacks of mild jaundice, fatty stools are the symptoms ascribed to it. Perhaps the nearest one ever comes to a positive diagnosis is the syndrome of adult megacolon with sprue and steatorrhea (see p. 121) in which one must assume that the pancreas is involved. (See Pratt: *Pancreatic Disease*, J. A. M. A. 120: 175, Sept. 19, 1942.)

Subphrenic abscess must be classified as an inflammation of the upper right quadrant, but the signs are more likely to appear in the lower chest. The subject is treated on page 433.

TUMORS OF THE UPPER RIGHT QUADRANT

Palpable Liver.—

CAUSES OF PALPABLE LIVER	PER CENT
Passive congestion (heart failure)	70
Portal cirrhosis	14
Cancer	12
Abscess	1
Leucemic infiltration	1
Syphilis	2

Differential diagnosis obviously depends on attendant signs. Enlargement of the liver with ascites is either heart failure or cirrhosis in such preponderance as virtually to exclude every other consideration.

Palpable liver without ascites suggests cancer, syphilis, leucemia, splenic anemia first, and passive congestion and cirrhosis second.

Portal cirrhosis is associated with alcoholism in every case known to me. The asinine opposition to this etiologic conception which has been advanced by experimental pathologists and biometricians has never rocked the common sense of clinicians. The experimental pathologists rested their case on the failure to produce cirrhosis by feeding alcohol to animals. However comforting these conclusions might be to the habitual toper, they had no validity because they failed to imitate human conditions. Experimental animals do not live long enough to acquire cirrhosis. Cirrhosis of the liver is the result of a lifelong labor of love. It is of slow development. Of late years, however, experiments have been devised which in animals produce liver changes comparable to the cirrhotic liver of man. Allan, Bowie, McLeod, and Robinson (Brit. J. Exper. Path. 5: 75, 1924) found that in depancreatized dogs kept alive with insulin for long periods, fatty livers regularly develop. Following this lead Connor and Charkoff (Proc. Soc. Exper. Biol. and Med. 39: 356, 1938) produced cirrhosis of the liver resembling the human form in 4 out of 16 dogs, which were receiving a high fat diet and large doses of alcohol. Connor (Am. J. Path. 30: 165, 1940) was able to produce cirrhosis in 7 out of 20 rabbits given a high fat, low carbohydrate diet with alcohol by stomach tube for months to the limits of tolerance. And the same investigator (Connor: Am. J. Path. 14: 374, 1938) was able to trace in human alcoholic subjects all the successive changes in the liver from fatty infiltration (the large, smooth, fatty liver the most constant finding in alcoholism) to the hypertrophic liver to the atropic cirrhotic liver.

I have a series of case records in which I think I can discern the recognition of these stages clinically. The typical example is the habitual excessive toper of thirty-five to forty years of age who scoffs at any suggestion of ill health, but who has a palpable liver definitely a finger or two fingerbreadths below the costal margin: it is soft and there is no ascites. Later, the liver is larger, there is dyspepsia and perhaps a gastric hemorrhage. Finally, with full decompensation there are ascites, some jaundice, hemorrhoids, possibly frequent hemorrhages, and the liver may have receded, though usually it is well down toward the umbilicus.

The etiologic factors of 112 cases of cirrhosis of the liver investigated clinically were as follows:

Alcohol	52
Syphilis	49
Typhoid	18
Cholecystic disease	15
Malaria	12
Anemia	3
Hypertthyroidism	2

The symptoms were:

Abdominal distention	112
Asthenia	73
Emaciation—loss of weight	62
Flatulence	60
Abdominal pain	57
Jaundice	43
Constipation	41
Diarrhea	32
Gastrointestinal hemorrhage	20

(Op. cit.)

The signs were:

Ascites	112
Edema lower extremities	83
Enlarged liver	69
Collateral cumulation	57
Palpable spleen	49
Hernia	47
Hemorrhoids	46

(Op. cit.)

In general, the weight of the liver is consistently under a theoretical normal of 1,800 grams, but in about a quarter of cases it is heavier. The spleen is consistently heavier than normal.

The term atrophic cirrhosis applies to the diminution in size of the lobule not to an atrophy of the whole organ. Every student who wishes to understand the nature of cirrhosis should study specimens of livers with blood vessel injection, such as those of McIndoe (*Arch. Path. & Lab. Med.*, 1927, 1928).

Biliary cirrhosis, in my opinion, is identical with hemolytic jaundice. Hanot wrote his original account before Hayem described hemolytic jaundice in 1898. Reading Hanot's account today, it is inescapable not to reflect that he was describing the same sort of cases as Hayem described. There is the appearance of symptoms in young life, the familial incidence, enlarged liver and spleen, and jaundice. In only one respect do the accounts differ. Hanot described the jaundice as being continuous and deepening once it started, not coming in crises or attacks; but that may be explained by careless observation, or the idiosyncrasies of his few cases. The final resemblance, added by modern surgery, that splenectomy will cure both makes them, for clinical purposes, indistinguishable.

Curveilhier-Baumgarten syndrome is a form of cirrhosis or atrophy of the liver due to persistence of a patent umbilical vein. The physical signs are distended abdominal veins, ascites, splenomegaly, anemia, leucopenia, and hematemesis. The age of onset is fifteen to seventy years, with most cases from forty to sixty. (See Armstrong, Adams, Tragerman and Townsend: *Ann. Int. Med.* 16: No. 1, Jan., 1942.)

Hemochromatosis produces an enlarged liver and spleen. In 60 per cent of cases the liver was slightly enlarged, in 10 per cent moderately, and in 4 per cent markedly enlarged; no enlargement was found clinically in the rest, but at autopsy it was enlarged in 95 per cent of cases. The spleen was en-

larged slightly to markedly in about 50 per cent of cases. The cause of the condition is a disturbance of iron metabolism with deposits of hemosiderin and other pigments. The nature of the disordered nutrition is not understood. The enlargements of the liver and spleen are due to deposits of iron, causing a cirrhosis. The pancreas is also affected, resulting in the diabetes characteristic of the condition. There is a peculiar skin pigmentation, which gives it the name—bronzed diabetes. It is predominantly an affection of middle-aged males.

Syphilis of the liver is one of the four possibilities that leap to the clinician's mind when confronted with a palpable liver, chronic passive congestion, cirrhosis, and cancer being the other three; and it is strange to find how rarely it occurs according to statistical report (see p. 469). Statistics of this kind, however, are subject to considerable interpretation. McCrea found 0.2 per cent clinically recognized cases of syphilis of the liver in 27,000 medical examinations and 1.5 per cent recognized in 3,000 post mortems. This was in pre-Wassermann times. Stokes found 15 per cent of 419 patients with various forms of syphilis had a palpable liver or spleen, which, as he points out, checks with the current conception of the statistics of the prevalence of syphilis; i.e., if 10 to 15 per cent of the population has syphilis and if 1.5 per cent of autopsies show syphilis of the liver, it would mean that in 15 per cent of clinical cases of syphilis, liver involvement can be demonstrated.

Of the various forms of syphilis of the liver, few of them are of any clinical importance. Thus the early hepatitis accompanying the florid stage is like the gastritis, etc.

Acute syphilitic yellow atrophy is so rare that only one syphilographer has reported as many as 3 cases (Richter). Later *syphilitic hepatitis* recognized by functional tests is very difficult, if not impossible, to disentangle from *arsphenamine* liver.

Latent liver and spleen, asymptomatic and usually overlooked diffuse enlargement on physical examination are nevertheless good sign posts in a general diagnostic survey and more than reinforce the positive Wassermann. This syndrome of enlarged palpable liver and spleen, with or without anemia, is probably the most interesting aspect of hepatic syphilis to the clinician. It has obviously highly imitative possibilities. Korns (Korns: *Tertiary Syphilis of the Liver Simulating Banti's Syndrome*, *Am. J. M. Sc.* 129: No. 6, June, 1930) reviewed Banti's syndrome with the view of determining whether it was always syphilitic in origin: he decided that only 36 out of 120 cases were unquestionably syphilitic, but the debate indicates how much consideration the clinician must give to the question in the presence of a big liver, spleen, and anemia. Stokes has, as usual, a suggestive series of case histories showing the imitative tendencies of the syndrome: it is too long to be quoted here, but should be read carefully by every clinician (*Modern Clinical Syphilology*). Pain, jaundice, attacks of vomiting, cachexia, loss of weight, etc., have suggested peptic ulcer, gastric cancer, gallstones, pancreatic cyst and many other conditions to accomplished clinicians.

Ascites as a sign was present in about one-third of all forms of syphilitic liver in the Stokes' series. Nor in my experience are the accumulations massive, so ascites is not a sufficiently prominent sign to make the confusion with cirrhosis troublesome. The old debate as to whether cirrhosis is syphilitic has lost its note of clamor and is now only a faint whispering in the corridors of science.

Gumma of the liver is next to the hepatosplenic syndrome the common form of liver syphilis of clinical importance. These livers, when seen at autopsy and when they reach the clinic, are lobulated and broken up by bands of scar tissue, the site of all healed gummatous infiltrations. Fresh gumma may also be present. There is a great predilection for these to occur in the left lobe (49 out of 89 cases) and for the mass to appear in the epigastrium in the left quadrant. The liver is usually fixed by hepatitis to the anterior abdominal wall or somewhere where the sign of respiratory excursion does not help the clinician to identify a liver tumor.

Cancer of the Liver.—The liver, like the lung, is a natural bed for the location of metastases. When palpable, such a liver is likely to be very hard and more likely than any other liver to have a perceptibly uneven and lobulated edge.

Primary tumors of the liver are very rare. The so-called hepatoma, a massive carcinoma, is probably the commonest. Angioma and sarcoma have been described.

Cholangioma, a tumor of the bile duct cells, is almost as common as hepatoma. The clinical picture showed abdominal mass (77.5 per cent of cases), abdominal pain (72.5 per cent), jaundice (60 per cent), ascites (60 per cent), weight loss (52 per cent), peripheral edema (42.5 per cent), gross bleeding from nose, stomach, bowel (22 per cent). (Wilbur, Wood and Willett: *Primary Carcinoma of the Liver*, Ann. Int. Med. 20: No. 3, March, 1944.)

Nonparasitic cysts of the liver produce a mass in the right upper quadrant. They may be multiple or single. The favorite site is the right lobe. The age range is ten months to eighty-two years. One was reported which contained 10,000 c.c. of fluid. The cause is entirely speculative. Pain was present in about one-fourth of the reported cases. Nausea and vomiting and jaundice are accompanying symptoms. (See McCaughan and Rassieur: *J. Missouri M. A.* 4: No. 10, Oct., 1943.)

Abscess of the liver is rare in temperate climates. The multiple abscesses of pyelphlebitis following appendicitis are not subject to clinical diagnosis. Amebic abscess is usually single and, in 75 per cent of cases, located in the right lobe. As much as 8 quarts of fluid may be removed from one of these. The diagnosis is not difficult when a large liver is encountered in an amebic district.

Echinococcus cyst is also rare in the Western Hemisphere. Most cases are in Greek immigrants. The tumors usually become enormous. They resemble ascites or pregnancy at term. In a Greek or Norwegian of the peasant class recently arrived in America, such a picture should always bring to mind *Echinococcus*.

OTHER TUMORS OF THE RIGHT QUADRANT

Carcinoma of the gall bladder is rare. It is seldom recognized clinically or even at operation. Symptomatically it differs very little from cholecystitis except that the symptoms tend to be progressive rather than intermittent.

Situs inversus may produce tympany in the right upper quadrant.

Tumors of the Pancreas.—Besides carcinoma, cysts of the pancreas occur. They are, however, of the utmost rarity. They are divided into the true cysts due to proliferative epithelium, retention cysts, and pseudocysts of the lesser peritoneal cavity following acute pancreatic disease. Some of them attain enormous size. (See Stillman: *Am. Surg.* 90: 58, 1929. See also Gilbride: *Tumors of the Pancreas, J. A. M. A.* 83: 984-9, Sept. 24, 1924; Einhorn: *Pancreatic Cysts, Am. J. M. Sc.* 169: No. 3, March, 1925.)

Pancreatic lithiasis is probably not as rare as might be expected. The symptoms are, naturally, usually ascribed to gallstones, which frequently co-exist. Whether found at autopsy or not, depends upon the care with which the search is made. Opie found two cases in 1,500 autopsies, while Lüdin (*Arch. f. Verdauungskr.* 63: 273, 1938) when diligently searching each pancreas found stones in 28 cases in 542 autopsies. The clinical diagnosis may be suggested by repeated attacks of upper abdominal pain, with nausea and vomiting, and, especially, fatty diarrheas. Tenderness and rigidity are present locally. The stones are always calcified and show on an x-ray plate. The source of calcification is mysterious as the pancreatic secretion does not contain any calcium salts normally. It is postulated that infection of the pancreas causes a change in the chemistry of the secretion. (See Moss and Freis: *New England J. Med.* 227: No. 16, Oct. 15, 1942.)

Calcareous pancreatitis, in which the body of the organ is calcified, causes symptoms and signs of generalized pancreatic disease, namely, weakness, intractable diarrhea, and weight loss. It produces x-ray shadows. (See Pasternaek: *Ann. Int. Med.* 19: No. 8, Nov., 1943.)

Carcinoma near the ampulla of Vater produces a characteristic picture of slowly increasing painless jaundice, chills, and fever. The patient finally has a deep metallic jaundice that is unmistakable. A palpable tumor is rare. These are customarily spoken of carelessly as cancer of the head of the pancreas. Actually the commonest tumor in this region is of the cells of the duct epithelium either at the ampulla of Vater or more frequently above. They are scirrhus, the sections showing large amounts of fibrous tissue. The less frequent type arises from the parenchymal, or acinar, cells of the pancreas. The symptoms and signs of the two types, however, differ very little. (Kiefer: *Carcinoma of the Pancreas, Arch. Int. Med.* 40: No. 1, July, 1927.) When carcinoma of the pancreas does occur, jaundice is a terminal event, superimposed on a history of emaciation and cachexia. In Speed's series 90 per cent had cachexia, 80 per cent jaundice, and 61 per cent pain. (*Am. J. M. Sc.* 160: 1, 1920.) Sharpe and Comfort (*Carcinoma of the Papilla of Vater, Am. J. M. Sc.* 202: No. 2, Aug., 1941) state that it is a mistake to assume that jaundice is always painless in tumors near the head of the pancreas, pain being the chief

symptom in 16 of 24 patients. The liver was palpable in 26 of Kiefer's 33 cases. A dilated gall bladder was felt in 15 cases.

Carcinoma of the hepatic flexure of the colon was the location of 53 cases of colon carcinoma in White's series (Op. cit.). Retroperitoneal tumors occurred in the upper right abdomen in 6 out of 45 collected cases.

C. Diseases of the Lower Right Quadrant of the Abdomen

Of mechanical derangements we have already considered intestinal obstruction due to intussusception, strangulated hernia, impacted gallstones, carcinoma of the cecum. Ectopic gestation has also been considered.

INFLAMMATORY LESIONS OF THE RIGHT LOWER QUADRANT

Appendicitis leads the list of inflammations of the right lower quadrant and the whole abdomen. The classical succession of events which point to appendicitis—pain or discomfort arising in the epigastrium, moving to the umbilicus, then to McBurney's point, nausea, vomiting, fever, tenderness over McBurney's point and rigidity of the right-sided muscles and leucocytosis occur, I should say, in just that way and just that succession in about 80 per cent of cases.

It is the 20 per cent remainder that gives the trouble. And about them it should be emphasized that appendicitis can do nearly anything, nearly any place in the body. With any acute abdomen of any kind at any age appendicitis should lead the lists of suspects. It may be painless, or the pain may be anywhere, depending on whether the appendix is retrocecal or attached to the sigmoid, or female adnexa. Fever may be absent. The leucocyte count may be low. The patient may not appear very sick.

As to complications, I do not see that it is possible or important to determine whether or not rupture has occurred. The "dangerous period of calm" following a stormy onset should be remembered by every clinician: it probably signalizes the moment of perforation or the onset of gangrene. Subphrenic abscess, a rare complication, has been discussed (see p. 433).

As a matter of curiosity more than scientific value, I refer to the "Queries and Minor Notes" column of the *Journal of the American Medical Association* for July 13, 1935, where, in response to a request for a list of the important signs (not symptoms) in all types of appendicitis, no less than forty-one signs were described. And not content with this, a correspondent in a later issue added six more. And neither list included Brittain's sign (*Am. J. M. Sc.* 182: No. 2, Aug., 1931), which is sudden retraction of the right testicle on palpation of the lower right quadrant when gnagrenous appendicitis is present. Most of these signs are either spontaneous or elicited spasm of some set of muscles and all the clinician needs to remember is that the inflamed appendix may lie over any one of several sets of muscles in the pelvis or elsewhere and cause consequent spasm. Thus Cope's sign, "The psoas muscle is stretched by extending the thigh, causing pain down the leg." Any sign elicited by dilating the rectum with air or a barium enema, or even, except for special reasons, a rectal examination at all should be forgotten: such procedures are to be condemned. As

are procedures which involve kneading or manipulation of the abdomen like Rovsing's sign—the production of pain over McBurney's point by palpating or massaging the descending colon.

The patient with acute appendicitis should not be moved about too much but every experienced clinician faced with the decision of announcing acute appendicitis will want to be certain first that the entire syndrome of abdominal pain, rigidity, fever, and leucocytosis is not due to a right lower lobe pneumonia, a pleurisy, or a pericarditis. The lower thoracic nerves run along the intercostal spaces and terminate by supplying the skin and muscles of the anterior abdominal wall. If irritated, as by a pneumonia or pleurisy, in their upper course the pain and muscle spasm are referred. (See Frissell and Kay, Symptoms of Appendicitis in Acute Pericarditis, *Am. J. M. Sc.* 163: No. 1 Jan., 1922.)

Dr. Condit W. Cutler (Errors of Surgical Diagnosis, *Am. J. M. Sc.* 187: No. 6, June, 1934) records that at the regular weekly conferences of the surgical divisions at the Roosevelt Hospital, New York, the following were found

Acute appendicitis heads the list of diagnostic errors. This was partly because appendectomy is the most frequent operation performed and partly because the diagnosis is naturally made in a rush, without time for mature reflection. During three years in his division, out of 389 cases the diagnosis was made incorrectly in 28 cases, an error of 7 per cent, five times salpingo-oophoritis was present, four times (3 in children) enteritis was found. Pneumonia—1 error; rupture of cyst or twisted pedicle of ovarian tumor—2 errors; acute cholecystitis—2 errors; carcinoma of transverse colon with acute obstruction—1 error; typhlitis (perhaps regional ileitis)—3 errors; abnormality of appendix, not appendicitis (fecaliths, kinking of appendix)—5 errors.

Chronic Appendicitis.—This was in former times a favorite diagnosis to explain chronic digestive symptoms, pain over the appendix region, "colitis," mucous colitis, etc. Of late years it has come in for severe criticism (see Alvarez: *J. A. M. A.* 114: No. 14, April 6, 1940. See also Sagal and Heineman, *Rev. Gastroenterol.* 8: 286, 1941. See also Heintzelman, J. H. L., and Evans, F. A.: Question of Chronic Appendicitis, *Am. J. M. Sc.* 201: 651-655, May, 1941). The objections are first, that the appendix does not undergo chronic inflammatory changes (this does not refer to recurrent acute appendicitis, or the residual sequelae of acute appendicitis); second, that the patients are all neurotics, and third, statistically that removal of the appendix under this diagnosis results in relief in only one out of a hundred cases. Warren and Ballentine (*J. A. M. A.* 117: No. 12, Sept. 20, 1941), on the contrary, conclude that "chronic appendicitis is a clinical entity." Personally I find myself on the side of the angels: I do not believe in chronic appendicitis.

Regional Ileitis.—In 1932 Crohn, Ginzberg and Oppenheimer (*J. A. M. A.* 99: 1323, 1932) described a condition of the terminal segments of the small intestine to which they gave the name regional ileitis. It is apparently a granuloma usually located in the terminal ileum, occasionally invading the cecum, and also found in "skip areas," or local involvements higher up in the intestine, as far as 18 inches above the cecum. There are large mesenteric

lymph nodes signaling the areas of intestinal involvement. Fistulae, both internal to other parts of the intestine and external through the abdominal wall (usually through the operative scar of an appendectomy), or perianal, or rectovaginal are part of the picture. There is little if any spontaneous tendency to heal. In a general way it belongs to such conditions as sarcoid which are histologically granulomatous, but in the pathologic course act like neoplasms.

The symptoms are pain (often mistaken for acute appendicitis) and then bouts of diarrhea with fever, and finally, low grade obstruction. A mass is usually palpable in the region of the terminal ileum after the condition has lasted some time. It is very chronic in its progress, the anamnesis in Crohn's series showing a duration of from 1 to 15 years or more. The x-ray is of final value in the diagnosis.

Ileocecal tuberculosis is a naturally common complication of pulmonary tuberculosis. As a primary disease it is seldom seen any more (with the rigid enforcement of dairy inspection). It may be suspected when there is pain, diarrhea, blood in the stools (it is ulcerative), and onset of weight loss, and increased temperature. Tenderness and a mass are usually elicited. The x-ray plate is an indispensable form of confirmation.

Cold abscess, or psoas abscess, and the possibilities of the burrowing of pus must never be forgotten during the examination of this region. Allport (*The Diagnosis of Retroperitoneal Enlargements*, J. A. M. A. 54: No. 25, June 18, 1910) called the cold abscess "the cause of the greatest and most confusing of all elements which cloud abdominal diagnosis," and added, "If one were looking for a universal point of departure for a system of differential diagnosis, one need go no further than a study of the many sided aspects of chronic suppurations." Not only does the infection from a tuberculous spine travel down the psoas muscle, but pulmonary suppurations (empyema) burrow down from the lung beneath the diaphragm and lumbar fascia and present as a fluctuating mass either in the right or left lower quadrant or in the lumbar regions. I once heard a patient recite a history of long-standing pain first in the chest, then in the lumbar region, then round the kidney and ureters, until finally an abscess pointed below Poupart's ligament, and when drained a broken hypodermic needle was recovered. He then remembered that years before tetanus antitoxin was administered to him in the back and some talk of the needle breaking off came back to him.

Dr. Allport made a good point of insisting on the "doctrine of averages" in these puzzling cases, the doctrine pointing the lesson that a swelling, painless and irregular, possibly fluctuating and incapable of association with any organ should be a cold abscess. Malignant disease is usually of organs, chronic abscess usually involves fascial planes and spaces. By association with any organ he meant bleeding from the bowel for the sigmoid, hematuria for the kidney, vomiting for obstruction, etc.

Ballooning of the left lower abdominal quadrant has been described by Stetten as an early sign of perforated duodenal ulcer (*Am. J. M. Sc.* 174: No.

2, Aug., 1927). The explanation is that perforation produces first rigidity of the upper right abdominal muscles, then perhaps because the duodenal contents seep down the omentum to the right, the right lower abdominal musculature becomes tense; third, the left upper becomes tense, leaving the lower left flabby, and it is ballooned if the case is seen early enough.

TUMORS OF RIGHT LOWER QUADRANT

RELATIVE FREQUENCY.—From combined medical, surgical, and gynecologic services of several hospitals the following approximate figures are suggested:

Tumors of the lower half of the abdomen (midline or presenting to right or left):

	PER CENT
Pregnant uterus—so numerous that listing would upset the statistical record.	
Fibromyomata of the uterus	31½
Salpingitis	31½
Ovarian cyst	21
Tubal pregnancy	6
Solid ovarian tumor	4
Malignant tumor uterus	3
Cyst of broad ligament	1½
Distended bladder	1½

Tumors of the right lower quadrant alone:

	PER CENT
Localized appendiceal abscess	34
Salpingitis	22
Ovarian cyst (right)	20
Tubal pregnancy (right)	6
Carcinoma of cecum	6
Ileocecal tuberculosis	5
Ulcerative colitis	3
Tumor of abdominal wall	1
Intussusception	0.5
Regional ileitis	0.1
Retroperitoneal tumors	Too rare to be estimated.
This list needs little further comment.	

Broad ligament cysts are usually a form of hydrosalpinx, and the incidence statistics merge. The true cysts arise from the parovarium.

Simple **cystadenoma of the ovary** is the most frequent ovarian tumor. Then in order of frequency come papillary cystadenoma, carcinoma of the ovary, chocolate cysts of endometrial origin, dermoid cysts, fibroma and sarcoma (usually bilateral).

Carcinoma of the cecum constitutes 14 per cent and carcinoma of the ascending colon 12 per cent of all carcinomata of the colon. The age distribution of carcinoma of the colon is between the ages of 40 and 70 in 66 per cent of cases. The average duration of symptoms before consulting a physician

was eight months. The symptoms and signs of carcinoma of the cecum or ascending colon in the order of frequency are:

1. Abdominal pain or discomfort—diffuse dull pain. The pain is usually periodic, the intervals of relief getting shorter as the obstruction increases. Often the patient has been treating himself for indigestion with cathartics and dietary restrictions. In about 10 per cent of cases there is no pain. In carcinoma of the cecum the pain, when it becomes localized, is in the right lower quadrant.

2. Weight loss—from 10 to 80 pounds.

3. Anemia and pallor.

4. Obstruction not common in cecal and ascending colon carcinomata because the contents of the terminal ileum are liquid and there is little difficulty in passing the tumor. Borborygmus may be the only indication of obstruction.

5. Constipation, diarrhea, gross blood or mucus in the stool, or tarry stools, are seldom features of right-sided tumors. (See White: *The Diagnosis of Carcinoma of the Colon*, Am. J. M. Sc., 186: No. 5, Nov., 1933.)

Seventy-five out of 90 cases of intussusception occurred at the ileocecal valve, the small intestine invaginating into the large. (Holt and Howland: *Diseases of Infancy and Childhood*, N. Y., Appleton, ed. 9, 1928, p. 321.) Tumor in infants can be made out in nine-tenths of all cases. In adults, however, I have twice felt a tumor the size, shape, and consistency of half an unpeeled banana. They were very puzzling; the diagnosis was made only at operation.

Retroperitoneal tumors occurred in the right iliac fossa seven times in a series of 45 such cases.

D. Diseases of the Left Lower Quadrant of the Abdomen

MECHANICAL DERANGEMENTS.—Intestinal obstructions due to volvulus or fecal impaction are the only common mechanical derangements in the lower left quadrant, and they are not very common. Fifty per cent of all cases of volvulus occur in the sigmoid region. In 80 per cent of such cases the patients are males over fifty years of age. The signs of volvulus here are usually less acute or alarming than at other sites of intestinal obstruction. Meteorism is usually the first. Discomfort or pain in the *region of the cecum* follows. Visible peristalsis is very rare. Constipation is absolute after passage of the first stool emptying the sigmoid distal to the obstruction. Blood and mucus in the stool are uncommon. Nausea and vomiting come late. The stethoscope may help in diagnosis. The sigmoidoscope is more valuable.

Impaction due to fecal masses, enteroliths, gallstones, pinworms, gives a variable picture. Obstruction is seldom complete, and spasms of pain, cramps, meteorism may be followed by the passage of a liquid stool, or fecal masses. Enteroliths (calcified fecal masses) usually become canalized, bringing on symptoms of the patient assuming a certain position, followed by a liquid stool.

INFLAMMATORY DISEASES OF THE LOWER LEFT QUADRANT

In mucous colitis the colon is palpable usually in the sigmoid region in 91 per cent of cases. (Series of White and Jones: *Arch. Int. Med.*, 1940.) Ulcer-

ative colitis produces tenderness and rarely a palpable colon (the abdominal muscles are too tense to allow of its palpation). The same is true of amebic colitis. Diagnosis in these diseases is made on the basis of the symptoms, the number and character of the stools, on sigmoidoscopic and x-ray examination rather than on physical signs.

Sigmoid Diverticulosis and Diverticulitis.—*Diverticula* are not uncommon findings at autopsy on the bodies of elderly people in all parts of the colon. In one series 5.67 per cent of colon diseases were diverticula. When localized to any one region, 77.8 per cent are in the sigmoid. They are acquired, due to protrusion of the mucosa through the longitudinal muscular bands of the colon. The muscular coat of the colon is piled up in three longitudinal bands. Between these bands the circular muscular coat is thrown into folds or sacculations. Pits in the mucosa occur at these points and when the longitudinal muscular coats become weakened with age or through constipation, meteorism, or pressure of any kind, they break through, creating *diverticula*, the walls of which in thickness are no more than the peritoneal and mucosa coats.

The age incidence is striking—15 per cent occurred between forty and forty-five years, 37 per cent between fifty and sixty, and 32 per cent between sixty and seventy years.

Diverticulosis itself makes no trouble; only when diverticulitis occurs.

Twenty per cent of sigmoid diverticula become infected. Those with a narrow neck at the colonic lumen are most prone to do so.

It is useful to distinguish between acute and chronic forms of sigmoid diverticulitis, the chronic form may, of course, suddenly flare into the acute form.

The onset may be acute with fever, localized pain, tenderness, rigidity, and tumefaction—"left-sided appendicitis of the aged"—as it has so often been called.

In the chronic form with gradual onset the diverticula can drain, but a low grade inflammation, involving the peritoneal coat occurs. The symptoms are pain, constipation alternating with diarrhea, blood, pus and mucus in the stool. A tumefaction or an indurated segment of bowel can be made out in 31 per cent of cases. Urinary symptoms due to attachment of an inflamed diverticulum to the bladder occur in 26 per cent of cases. Rupture into the bladder occurs, Mummery Lockhart reporting 22 such cases in 400 cases of diverticulitis.

The complications are perforation and carcinomatous degeneration. The signs of perforation are sudden pain, peritonitis, and constitutional signs, as in perforation elsewhere.

The chronic condition is nearly always mistaken at first for carcinoma and often only exploratory laparotomy, or even histologic examination, reveals the true condition.

A puzzling and troublesome group of cases are those in which upper abdominal disease secondary to diverticulitis dominates the clinical picture while the sigmoid region is relatively or absolutely silent. O. H. P. Pepper has called attention to these (Pennsylvania M. J. 42: No. 9, June, 1939). Pylephlebitis, hepatic abscess, septicemia, and gall bladder disease may originate this way.

Young and Young, in a valuable review (New England J. Med. 230: No. 2, Jan. 13, 1944), furnish the following percentage table of symptoms and signs in ninety-one cases of diverticulitis:

SIGN, SYMPTOM, OR FINDING	CHRONIC DIVERTICULITIS	ACUTE DIVERTICULITIS
	%	%
Change in bowel habits	79	46
Rectal bleeding	33	20
General digestive complaints	53	41
Pain	61	95
Tenderness	67	93
Elevated temperature	12	80
Elevated white-cell count	19	80
Positive sigmoidoscopic findings	71	--
X-ray diagnosis (barium enema):		
Diverticulosis	98	88
Diverticulitis	78	84

Chronic ulcerative colitis, nonamebic, nonspecific unless the diplobacillus of Bargen is proved to be the causative agent, does not usually present physical signs, often not even rigidity. The symptoms are gradually increasing tenesmus, diarrhea, and bloody stools. The diagnosis must be made on the sigmoidoscopic findings of contracted colon with pus, mucus, and blood over the inflamed mucosal surface, and x-ray findings of contracted colon with loss of haustration.

The colon of amebic dysentery can also seldom be felt unless a localized abscess results. If the amoeba causes liver abscess it presents in the liver area. (Osler: Visceral Manifestations of the Erythema Group of Skin Diseases, Am. J. M. Sc. 127: 1, 1904.)

TUMORS IN THE LEFT LOWER QUADRANT

Tumors are rare in this quadrant, the only one that occurs with even fair regularity being *carcinoma of the sigmoid and rectocolonic area*. Thirty-six per cent of a series of carcinoma of the colon occurred in the sigmoid (White: Op. cit.). In persons under thirty years of age it occurs more often than any other form of carcinoma. The first symptom is pain or discomfort usually referred to the umbilical region or below, rarely to the lower left quadrant. However, the colon above the anosigmoid juncture is almost insensitive to pain. Constipation of rather sudden onset in a person who has previously had very regular bowel movements is always suspicious; the constipation becomes gradually more and more severe until it amounts to obstruction. In about one-third of cases, however, constipation is not mentioned, but the sudden taking up of the cathartic habit is almost as significant. Half the cases have blood in the stool. Most have mucus, but the patient seldom mentions this. Tumor, or a mass, can be palpated in over half the cases, depending partly on how late the patient presented himself. Ninety-six per cent of all anorectal malignancies can be reached by the palpating finger in the canal. X-ray and sigmoidoscope examination clinch the diagnosis in most instances.

Retroperitoneal tumors occurred in the left iliac fossa or left abdomen in nine out of a series of 45 such cases. (Osler: Visceral Manifestations of the Erythema Group of Skin Diseases, Am. J. M. Sc. 127: 1, 1904.)

Chapter II

THE EXTREMITIES

1. Short arms—achondroplasia.
2. Long arms—acromegaly.
3. Hyperesthesia, anesthesia, paresthesia, swelling, circulatory disturbances—cervical rib, scalenus anticus syndrome.
4. Swelling of the whole arm—postoperative mastectomy, removal lymph nodes, aneurysm, mediastinal tumor, lymphatic leucemia, sarcoma, lymphosarcoma, nephritis, heart failure (position edema).
5. Atrophy.
6. Scapula—winged scapula, Sprengel's scapula, sarcoma, osteomyelitis, exostosis.
7. Shoulder joint—arthritis. General discussion of arthritis.
 - a. Rheumatoid arthritis.
 - b. Osteo-arthritis.
 - c. Rheumatic fever.
 - d. Tuberculosis.
 - e. Gonococcic arthritis.
 - f. Gout.
 - g. Hemophilia.
 - h. Charcot's joints.
 - i. Intermittent hydrarthrosis.
 - j. Hypertrophic pulmonary osteo-atrophy.
 - k. Lupus erythematosus disseminata.

Examine for swelling, tenderness, limitation range of motion, crepitation, loss of muscle strength.

Percentage distribution of these among joints upper and lower extremity.

8. Bursae—subdeltoid bursitis, olecranon bursitis, syphilitic olecranon bursa.
9. Bones—osteomyelitis, rickets, Paget's disease, tumors.
10. Muscle tendons and fasciae.
11. Lymph nodes—lymphatic enlargements—Hodgkin's sarcoma, lymphatic leucemia, Boeck's sarcoid, tuberculous, epitrochlear syphilis.
12. Nerves—paralyses upper extremity, tremor, tetany.
13. Blood vessels—axillary aneurysm, Raynaud's disease, scleroderma.
14. Skin—ulceration, tularemia, sporotrichosis, Morvan's disease, scabies, ringworm, cold allergy.
15. Hand—Heberden's nodes, myxedema hand, acromegalic hand, Dupuytren's contracture, Volkmann's contracture, Osler's nodes (Major, R. H.: Physical Diagnosis, Philadelphia, W. B. Saunders Co., p. 355), ganglion, syphilitic dactylitis, writer's cramp, tetany, athelosis, wrist drop, claw hand.

16. Fingernails—clubbed fingernails, Hippocratic fingers.
17. Fat pads on arm.
18. Neoplasms.

The general internist in examining the extremities should start his mental procedure by trying to determine which structure or structures are involved; there are bones, joints, bursae, muscles, tendons, lymphatics, lymph nodes, nerves, arteries, veins, capillaries, skin, fat pads, and adventitious tissue, such as neoplasms or congenital remains.

Although the same general process may affect the same structures in either, there is a highly selective percentage tendency for certain diseases to affect either the lower or the upper extremity. The legs and feet bear the constant trauma of walking and hence it is perhaps natural that such conditions as gout, hemophilic joints, Chareot joints, and gonococcic arthritis should affect them more conspicuously than the arms and hands. The upper extremity tends to be the localizing point for rheumatoid arthritis, Raynaud's disease, scleroderma, and tularemia. In the following account we shall describe the general features first and then indicate the percentage occurrence between upper and lower extremity.

Short arms and legs are the primary sign of achondroplasia. They may indicate some endocrinopathy and a discussion will be found in the section on diseases of the endocrine glands.

Long arms and legs are primarily the sign of acromegaly. Other endocrine implications will be found described in the section on diseases of the endocrine glands.

Pain, anesthesia, swelling, circulatory disturbances of the arm should make one consider cervical rib or the scalenus anticus syndrome. They are often associated. Cervical rib would naturally produce an abnormal implantation of the scalenus anticus, but abnormal scalenus anticus implantation can occur alone without associated cervical rib. (Ochsner, Gage and DeBaKey: *Am. J. Surg.* 28: 669, 1935.)

Cervical ribs are found in about one out of every hundred dissections. The frequency with which they produce symptoms may be gathered from the Mayo Clinic report of finding 31 cases in a consecutive series of 80,000 patients examined.

Theoretically we should have a rib for each vertebra. The orangutan, chimpanzee, and gorilla have thirteen or fourteen. The cervical rib usually arises from the seventh cervical vertebra; 75 per cent are bilateral. They may make connection with the sternum, the first rib, or remain as unattached outgrowths, or present a joint in the middle (flaillike). (Henderson: *Mayo Clinics*, 1913.) Seventy per cent occur in females. Cervical ribs may arise from the sixth, fifth, fourth, or third vertebrae, but no cases producing symptoms have been reported except from the seventh. Supernumerary ribs from the lumbar vertebra are quite common but here also no syndrome associated with the anomaly has been recorded.

The symptoms of seventh cervical rib are due to the angulation required by the subclavian artery and the brachial plexus deviating over the super-

numery rib or by pressure of the artery or nerve by the misplaced scalenus anticus. The symptoms are therefore circulatory, nervous, or mixed.

Specifically, pain, numbness, tingling, cramps, ischemia, cyanosis, atrophy, and trophic changes are the symptoms noted in the order of their frequency.

Locally, a humplike appearance above the clavicle, cervical scoliosis, and abnormal forceful pulsation of the subclavian artery are the most frequent signs. Barker (*Monographic Medicine* 4: 61, 1917) states that a protuberance in this location must be differentiated from (1) inflammatory enlargement, (2) true tumor, (3) enlargement of salivary, thyroid or lymphatic glands, (4) aneurysm, (5) esophageal diverticulum, and (6) cervical rib. The x-ray is the final diagnostic proof.

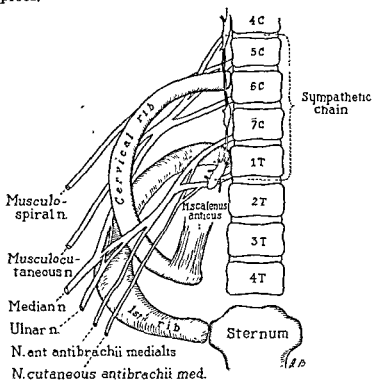


Fig. 47.—Cervical rib. Diagram of relationship of cervical rib, brachial plexus, and sympathetic cervical ganglia.

Symptoms rarely appear before adolescence and then are likely to be initiated by some kind of minor trauma or repeated trauma—firing a gun, playing the violin or piano. Once the symptoms begin, any prolonged use of the arm is likely to bring them on.

The symptoms noted are:

1. Excessive fatigue or tiring of the arm amounting to pain usually on use. As it is generally the inner strands of the plexus which are pressed on, the pain appears over the ulnar nerve and nerve of Wrisberg (cutaneous brachialis, distributed to skin on inner site arm).
2. Inability to extend fully the arm at the elbow.
3. Pain—brachial neuritis.

4. Anesthetic areas. Barker (J. Exper. Med , 1896). himself an example, found he had an area on the skin of the arm lacking in pressure and temperature senses, but retaining pain sense.

5. Tingling is a common symptom.

6. Atrophy of one or more groups of muscles.

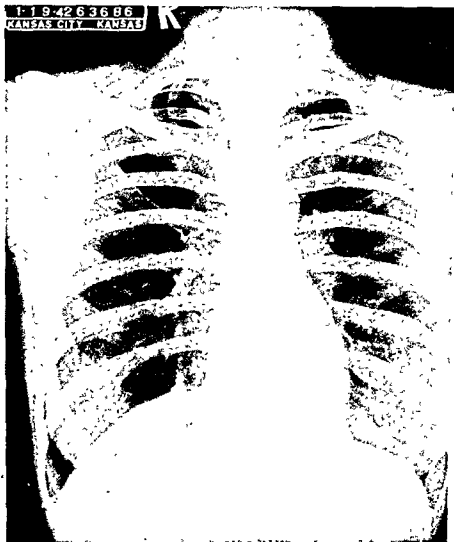


Fig. 48.—Bilateral cervical rib.

7. Cramps in the arm, usually after exposure to cold, or carrying a bundle. Cramps often precede pain. The patient has to use the other hand to straighten out the fingers of the cramped hand. Ischemia of the fingers usually goes with the cramping.

8. Inequality of pulses.

9. Trophic disturbances in fingernails, blebs on the skin, and hemorrhages under the nails.

10. Hoarseness—a difficult symptom to account for. The right recurrent laryngeal nerve loops under the subclavian artery at the point where the artery arches over the supernumerary rib. (Weissenstein: *Wien. klin. Rundschau*, 1903.)

11. Pupillary changes may occur. (Church: *Neurology of Cervical Ribs*, J. A. M. A. 73: No. 1, July 5, 1919.)

If the angulation of the artery is marked, sacculation amounting to aneurysm may occur, but I find no instance of rupture in the literature. A case in which the artery eroded the rib is on record.

Maldevelopment of the first dorsal rib may simulate cervical rib by similar mechanisms. (Briehner and Welch: *Surg., Gynec. and Obst.*, Jan., 1925.)

The scalenus anticus syndrome is in mechanical causation very similar to cervical rib. If the scalenus anticus muscle is misplaced in its insertion (which is normally at the tubercle of the first rib), it can easily be seen that the subclavian artery and the brachial plexus will be hooked up or compressed so that the same symptoms occur as in cervical rib. The scalenus syndrome probably does not show quite such a variety or severity of symptoms as cervical rib may produce. Pain in the arm and shoulder is the most frequent symptom and the one most complained of. No chronic pain is more simply relieved by surgical interference. (Spurling and Grantham: *J. Missouri M. A.* 38: No. 10, Oct., 1941.)

Other causes of pain in arm. See p. 92, Symptoms.

Swelling of the Arms and Legs.—Swelling of both arms is an unusual occurrence. Yater (Barton, W. M., and Yater, W. M.: *Symptom Diagnosis*, N. Y. Appleton, 1929) says it occurs in fat women during the menopause. Both arms swell with obstruction of the superior vena cava, or with rupture of an aortic aneurysm into the superior vena cava, but these are accompanied by swelling of the face, neck, and upper thorax, and in the latter condition, by cyanosis.

Swelling of both lower extremities is, of course, one of the commonest of physical signs in chronic passive congestion of the heart, anasarca, varicose veins. It also occurs as a consequence of iliac thrombosis, or rather thrombus at the junction of the iliacs with the inferior vena cava, but this is rare.

Swelling of one arm is caused by obstruction of the lymphatic or venous circulation. Removal of lymph nodes of the axilla during mastectomy is probably the commonest cause. I do not recall ever seeing the sign in Hodgkin's disease or lymphatic leucemia, but it is a possibility. A remarkable condition is thrombosis of the axillary vein from exertion, about which a considerable literature has accumulated. (See Lowenstein: *J. A. M. A.* 82: No. 11, March 15, 1924.) After exertion there is pain and swelling in the arm, and the vein can be felt as a hard cord in the axilla. Inflammatory swelling is caused by septic lymphangitis. Along the same line, tularemia and trichinosis should be remembered. Marinesco's "succulent hand" of syringomyelia is well illustrated in Bing and Haymaker's *Diseases of the Nervous System* (Fig. 91).

Lymphangioma, cavernous lymphangioma, and cystic lymphangioma (hygioma) may cause swelling of one arm. Nearly invariably the subject is a child. The cavernous lymphangioma is a spongy mass of dilated lymph spaces, which may involve the hand, the arm, or the tongue or lips.

Swelling of one leg is most commonly due to unilateral varicose veins or septic thrombophlebitis of the femoral vein, commonly called phlebitis, following pregnancy, pelvic inflammation, or appendicitis.

Uncommonly encountered is the unilateral (and often bilateral) edema of hereditary nature, which goes by the name of Milroy's disease, after its describer, William Forsyth Milroy of Omaha. Nothing can be added to his original description (New York M. J. 56: 503, 1892):

"On August 20, 1891, Mr. H. presented himself for examination for life insurance. . . . The applicant called my attention to his lower extremities. I found a condition of oedema involving the feet and extending up the legs to the knees. . . . Upon inspection, the leg presented a slightly rosy hue. . . . Mr. H. stated that this oedematous enlargement has existed from birth . . . that this enlargement of the extremities was a family characteristic which he had inherited from his mother. Fortunately for the purpose of this study . . . in 1883 a member of the family published a neat volume, giving the family history in America for a period of two hundred and fifty years. . . . The peculiarity now under discussion seems to have entered the family by marriage about 1768. . . .

"1. So far as known, in every case, with two exceptions only, the oedema was present at birth.

"2. The location of the oedema has in every case been limited to one or both lower extremities.

"3. The presence of the oedema is persistent, never having been known to disappear, temporarily or permanently, except in one instance.

"4. It has never been attended by constitutional symptoms, barring the two possible cases in which its first appearance was subsequent to birth.

"From these considerations it seems evident that the case under discussion is not one of angio-neurotic oedema."

Trophie, or filarial, elephantiasis is unfamiliar to me. A form called infectious elephantiasis is described by Homans (*Circulatory Diseases of the Extremities*, Macmillan, 1939). It is associated with an open lesion like an ulcer, through which infectious organisms reach the lymphatics.

Atrophy of one arm or one leg is usually due to a previous attack of anterior poliomyelitis. In the Tooth type of peroneal neuromuscular dystrophy one arm may be involved as well as the legs. Both arms atrophy in cases of amyotrophic lateral sclerosis. Both legs atrophy in Charcot-Marie-Tooth peroneal neuromuscular dystrophy: it is familial and hereditary, comes on in childhood, affecting the distal muscles, most often of the lower limbs; the hands and arms are usually also involved; clawhand in childhood is nearly diagnostic; during the process of dystrophy the muscles fibrillate; the disease usually becomes arrested about the age of twenty, and the face and trunk muscles escape. Progressive hypertrophic polyneuritis is a similar condition, familial, with muscular atrophy,

but also marked sensory changes—shooting pains, anesthesia, analgesia, loss of joint sense. Disuse atrophy (as from arthritis) seldom goes as far as the nervous and muscular disease.

Lymphedema of the limbs besides the varieties due to elephantiasis, filariasis, Milroy's disease, or those due to trauma or venous thrombosis include *cavernous lymphangioma*, *elephantiasis nostra*, *reflex* and *allergic* edemas.

Elephantiasis nostra is an intermittent edema usually of the leg. It seems to be a variety of Milroy's disease.

Trophic edema is associated with *causalgia*. It ranges from an agonizing hypersensitiveness of the skin and burning pain with little edema to great swellings of a limb in which pain and sensitiveness to touch are little marked. It is essentially probably a dysfunction of the nervous system.

Allergic Edema.—Homans (Arch. Surg. 40: 232, Feb., 1940) describes allergic edema, especially in patients who are allergic to their own ringworm infections. I have never seen such cases.

The Scapula.—Winged scapula is due to serratus palsy (*n. thoracalis longus*). Any of the causes of peripheral neuritis operate, as well as trauma such as swinging at a punching bag, carrying a knapsack (Ilfeld and Holder: J. A. M. A. 120: 448, Oct. 10, 1942), sleeping on outstretched arm.

Alar scapulae with variations of the contour of the internal or vertebral border of the scapula are discussed on p. 277.

Elevation of the scapula (Sprengel's deformity) consists in elevation and rotation, with shortening of the scapular muscles and limitation of abduction of the shoulder. The vertebral border, instead of being parallel to the spinous processes, is closer to the midline at the upper angle than the lower angle. It is believed to be due to malposition in utero, shows up in infancy or childhood and may become progressively worse as age advances. (Sprengel: Arch. f. klin. Chir. 42: 545, 1891.)

The scapula is relatively immune from osteomyelitis, sarcoma, and exostosis.

Shoulder—deltoid paralysis—is due to paralysis of the circumflex nerve (*n. axillaries*). The rounded contour disappears and the arm cannot be raised laterally, forward or backward. Trauma is the cause almost without exception. Rupture of the fifth cervical dorsal root from birth trauma, most often, and ordinary trauma, sometimes, present about the same syndrome, but the supra- and infra-spinatus, biceps and brachialis anticus are also likely to be involved, with anesthesia on the upper inner arm. The test of deltoid paralysis is to ask the patient to raise the arm with the elbow stiff, straight out laterally from the shoulder.

Arthritis may affect any joint. We have discussed arthritis of the spine on page 297. Arthritis may affect any joint of the upper or lower extremity. We will discuss the subject in general first and indicate special predilection of one form of arthritis for one joint last.

In examining a joint there should be systematic observation and record of the following points: (1) swelling, with or without other signs of inflammation

such as redness and heat; (2) tenderness; (3) limitation of normal range of motion; (4) crepitation; (5) loss of muscle strength; (6) muscular atrophy.

An enormous amount of pothier has resulted from attempting to classify arthritis. I have subjected myself to the perusal of enough of this to be able to testify that I never learned one thing from such discussion. It is all very well to have a category of neuropathic joints in which you place Chareot and syringomyelia, and to have hematopoietic joints in which you place hemophilia. But when it comes to infectious joints and you have tuberculous, gonococcal and acute rheumatic joints, you have there things about as much alike as a house, a reindeer, and a squirrel. And the confusion becomes acute when the chronic arthritides are classified as infectious and degenerative, or atrophic and hypertrophic. Since we know nothing whatever about their etiology or pathogenesis, let us put them down as separate entities and name them in a way that, for one thing, does not commit us to any etiologic theory and, in the second place, has become time honored so that everyone knows what we are talking about: in short, let us call them rheumatoid arthritis and osteo-arthritis. Furthermore, I here describe each joint disease as a separate entity without bothering to classify it:

1. **Rheumatoid arthritis** is a generalized chronic disease, affecting many joints.

The age incidence is in young life from twenty to fifty years with the peak at thirty-five years. Females are more subject (3 to 1) than males.

Pathologically the synovial membrane is affected first—inflammatory congestion and effusion into the joint. The joint cartilages become dull and red, there is a proliferation (pannus) of synovial membrane over the joint. Then, if no interruption of the process occurs, the cartilage is destroyed, there is atrophy and rarefaction of the bone, and ankylosis. In advanced and terminal cases the skin shows atrophic changes and becomes peculiarly smooth, shiny, and pearly-blue mottled.

Subcutaneous nodules, hard, movable, from the size of a pea to that of a walnut, near fingers, wrists, and elbows occur in about 10 per cent of cases.

The internal organs are remarkable free from disease changes, considering the profound and generalized change in the metabolism of the joints and skin.

The course of the disease is extremely variable. It may be interrupted at any stage. About 20 per cent of patients recover either spontaneously or under treatment. An additional 50 per cent show moderate to marked improvement, but are left with some deformity or disability. An additional 20 per cent are improved to some extent, so that the disease becomes static, but with ankylosis and considerable disability. In about 10 per cent of cases no improvement occurs with any form of treatment, and they progress to a terminal stage of complete helplessness.

In the moderately advanced or terminal stages the patients are familiar sights in hospital wards and in the infirmaries of almshouses and poor farms. They are pitiable objects, helpless and bedridden, obviously malnourished, and

naturally discouraged and melancholy. The spindle-shaped deformities of the fingers and characteristic bumping of the wrist point to a specific and unmistakable disease entity.

Associated diagnostic laboratory findings are (1) markedly increased blood sedimentation rate, (2) blood chemistry generally little changed, (3) mild anemia, no leucocytosis, (4) x-ray shows (a) early—thickening of the capsule of joint, increase in soft tissue shadows and changes in normal position of bones suggesting destruction of cartilage; (b) late—ankylosis, systematic decalcification, punched out areas, narrowing and obliteration of joint space.

The diagnosis of the moderately advanced or advanced case hardly ever presents any difficulty. How shall we suspect rheumatoid arthritis in the earliest stages? The onset is usually very insidious, abrupt enough to resemble acute articular rheumatism in about 10 per cent. The peripheral joints tend to be attacked first and symmetrically. Pain in the joints on movement. Single joints are occasionally, but very rarely, attacked first. There is low grade fever, tachycardia, and prodromes of loss of appetite and fatigue.

The type of individual attacked is with remarkable regularity the asthenic, viscerototic, underweight with a peculiar cold, shiny, atrophic, semicyanotic skin.

The second task of the clinician after arriving at a diagnosis of rheumatoid arthritis is to hunt for foci of infection—in teeth, tonsils, paranasal sinuses, prostate, and intestinal mucosa. More important than finding them is to evaluate them.

There has been a growing unanimity of clinical opinion that rheumatoid arthritis is an infectious process. The fever that accompanies most cases, the leucocyte content of aspirated synovial fluid, the frequency of associated focal infection, the agglutination of strains of hemolytic streptococci all point in that direction. But there are plenty of indications that such conclusions should be held suspended. The whole pathologic process in the joints is entirely unlike an inflammation and more like a degeneration. On pathologic grounds alone it would be more reasonable to call rheumatoid arthritis degenerative and osteoarthritis infectious (because bone infections cause an overgrowth of bone) rather than vice versa as is the custom at present. The removal of foci of infection alone never cures or averts a case of rheumatoid arthritis. As to the agglutination of streptococci, the difficulty is in finding a person, healthy or sick, whose serum will not agglutinate some strain of streptococci.

On the other hand, the atrophic nature of the changes, the somatic type of body build most of the patients have, the almost invariably poor nutritional environment and the very large number of cases that have an hereditary history indicate that it were wise to suspend judgment until more definite proof of the real causation is available.

Still's Disease, Felty's Syndrome.—Still, in 1897, described cases of progressively deforming polyarthritis with enlarged spleen and lymph node hyper-

plasia in children. A very similar condition was described by Felty in 1924, but in adults. It is generally agreed that these two syndromes are varieties of rheumatoid arthritis.

Spondylitis.—The spinal and joint changes of chronic arthritis are described on p. 692.

2. *Osteo-arthritis* is the other common form of chronic polyarthritis. Clinically, it is different from rheumatoid arthritis in that the subjects are older at onset (fifth and sixth decades), it tends to affect overweight people, it affects chiefly the knees, the spine and the fingers, its attack does not tend to be symmetrical, it is not migratory, is not accompanied by subcutaneous nodules, but by Heberden's nodes, the blood sedimentation rate is not accelerated, and it rarely causes complete invalidism.

Pathologic changes consist of: first, degeneration of the central part of the synovial cartilage (as distinguished from involvement of the edges as occurs in rheumatoid arthritis). A granular appearance of the cartilage results with the formation of pits, depressions, and erosions. There is proliferation of bone and spur formation, with considerable overgrowth of neighboring bone as the condition progresses. Cartilaginous proliferation at the edges of the joint becomes converted into bone and exostoses. Finally, the cartilage becomes nearly worn away and the bony surface presents a smooth, eburnated appearance. Loose bodies are common in the joint. Ankylosis is rare.

3. *Rheumatic fever*, acute articular rheumatism, is a generalized infection which may affect any or all of the joints, and the myocardium, endocardium, and pericardium. Ninety per cent of cases occur in children under fifteen years of age. It is evidently an infection, although other (nutritional) factors are present. It is a disease of poverty. Damp, cold climates and dwellings favor its development, although it has been reported in the tropics in large series (Wig: Indian M. Gaz. 70: 260, 1935 and Cooper: M. J. Australia 1: 714, 1935).

The typical case starts abruptly with fulminating signs of fever and swelling, pain, and inflammation of one or more joints. The most commonly affected joints are the knees, elbows, ankle, wrist, phalangeal, and shoulder. The spine and jaw are rarely affected. The arthritis is migratory, one joint being affected one day, others the next. The fever is likely to be high, and accompanied by profuse sweating and tachycardia. Prodromes in the form of sore throat and tonsillitis are common.

Variations in this typical course occur. In very young children joint symptoms may be minimal or absent. Larval forms with pallor, anemia, "growing pains," easy fatigability, and epistaxis occur.

4. *Tuberculous arthritis* affects in order of frequency spine, knee, hip, elbow, ankle, shoulder, and wrist. The spinal form is considered on p. 674.

The diagnostic points are (1) slow, insidious onset in one joint only; involvement of more than one joint very rare, (2) family history of tuberculosis or associated visceral or lymph node tuberculosis, (3) history of preceding trauma in 50 per cent of cases, (4) most common before the age of fifteen, but may occur at any age, (5) fever and slight loss of weight, (6) the joint shows

doughy swelling due to enlarged synovia rather than fluid, pain, stiffness, heat, and limitation of movement in natural exertion (limping or walking), muscular spasm, tenderness and, in time, muscular atrophy.

Confirmation of diagnosis by guinea pig inoculation, biopsy or tuberculin test. X-ray is of little value in early stages. In more advanced cases the essential features are rarefaction of bone and absorption of calcium and narrowing of the joint line.



Fig. 49.—Gonococcal arthritis of right hip.

Four stages have been described: (1) invasion physical, but no x-ray signs; may last weeks, months, or years; (2) tissue destruction; may last several months; (3) quiescence—joint swelling recedes; (4) healing—joint ceases to be painful, swelling goes down, fibrous tissue develops, ankylosis is usual.

5. Gonococcal arthritis in the great majority of cases occurs within ten to twenty days after urethral or cervical infection. At first a polyarthritis, it settles down into one joint in 95 per cent of cases. The joints involved in order of frequency are: knee (77 per cent), ankle (38 per cent), metatarsophalangeal (28 per cent), wrists (23 per cent), fingers (22 per cent), shoulder

(20 per cent), metacarpophalangeal (17 per cent), toes (14 per cent), hip 10 per cent), elbow (8 per cent), sacroiliac (6 per cent), intervertebral (5 per cent), heel (5 per cent), temporomandibular (2 per cent), sternoclavicular (2 per cent), olecranon bursa (0.7 per cent).

Swelling and accumulation of synovial fluid may occur early, but the usual picture of these joints shows pain, tenderness, and limitation of motion predominantly, with a more or less normal-appearing joint. Temperature between 100° and 104° F., and leucocytosis up to 25,000 are common. Blood sedimentation rate is accelerated. Migration to other joints is not usual. The



FIG. 50.—Gonorrheal exostoses.

condition may go on to suppuration, and subacute and chronic stages occur frequently. Any range of severity from mild arthralgia to purulent arthritis is possible. Tenosynovitis of wrists and ankles may be the only manifestation and often accompanies any acute joint involvement. The x-ray is not pathognomonic, but there may be a ground glass appearance of neighboring bones, and bony destruction, erosion osteolysis, and chondrolysis, with fibrous and bony ankylosis, can be seen in severe cases. The gonococcus complement fixation test is positive in over 80 per cent of cases after an incubation period of six weeks; dependence on this, however, presupposes very expert laboratory technique. It remains positive for years.

MISCELLANEOUS INFECTIONS.—Nearly any infection can cause arthritis (usually suppurative as a complication. Among those for which the clinician should be on the watch are: pneumococcic, usually suppurative, practically always secondary to pulmonary involvement, mono-articular in 75 per cent of cases, involving in order of frequency knee, shoulder, wrist, and elbow; undulant fever, nonsuppurative or suppurative, varying from arthralgia to gross destruction with ankylosis; typhoid, nonsuppurative, usually spondylitis, but may affect any joint; puerperal sepsis, usually suppurative, occurring in about 25 per cent of cases; septic arthritis from staphylococcic or streptococcic infection may follow a wound or be metastatic, usually suppurative, affects knee, hip, or shoulder more frequently than ankle, elbow, or wrist, is usually mono-articular.



Fig. 51.—Gout.

6. Gout in its first attack is almost always mono-articular, in 75 per cent of cases involves the big toe and next most commonly the olecranon region, although nearly any peripheral joint may be the site. The vertebral, temporomandibular and sternoclavicular joints are never involved; I agree with Hench that such involvement throws great doubt on the diagnosis.

The initial attack is usually very severe with great pain, redness, heat, and swelling in the joint. Later attacks may be of all degrees of severity. The attack comes on very suddenly, often following a surgical operation, hard walking (such as on a hunting trip), or a festive indulgence in the pleasures of the table and the bottle. The blood uric acid is raised, often as high as 10 or 15 mg. during an attack. The x-ray plate shows no changes in early cases: later the classical findings are punched-out areas in the bone.

Tophi are pathognomonic, but occur in only about 60 per cent of cases, and then usually only after the disease has lasted ten years or more. The site

of occurrence in order of frequency are the helix of the ear, knuckles, hands, toes, feet, fingers, heel, and even in nose and eyelids. They are small, whitish, or yellowish, painless nodules which may ulcerate through the skin. The contents should be examined chemically and under the microscope for monosodium urate. An attack lasts from twenty-four hours to several days, and between attacks the joint is painless and functions normally.



Fig. 52.—Gout of the elbow. The olecranon bursa is distended; its surface is rough, and subcutaneous tophi can be felt; the fascia above the olecranon is red and tender. This is next to the commonest site for gout, the commonest being the first metatarsophalangeal joint.



Fig. 53.—Gout of the big toe.

The diagnosis of gout should never be missed when a man (98 per cent of cases) of florid habitus in middle age suddenly flares up with a fulminating and extremely painful joint. The suddenness of onset, the severity of all the signs at this age can hardly be anything else, especially if the signs disappear

within 72 hours. I do not agree with those who think the therapeutic test (alleviation of symptoms with colchicine) diagnostic. During a single severe attack the joint is at first painful and tender, but not especially red, hot, or swollen; after about twelve hours redness and heat appear; about twelve to twenty-four hours later swelling of the peri-articular soft tissue appears and then the pain greatly lessens. The joint looks worse but feels better.

The course of gout is extremely variable. Dr. Philip S. Hench (Gout and Gouty Arthritis, J. A. M. A. 110: No. 6, Feb. 8, 1941) has described a pattern for gout which includes a larval pre-arthritis stage, a second stage during which the attacks last a few days and then go away, leaving no residual change

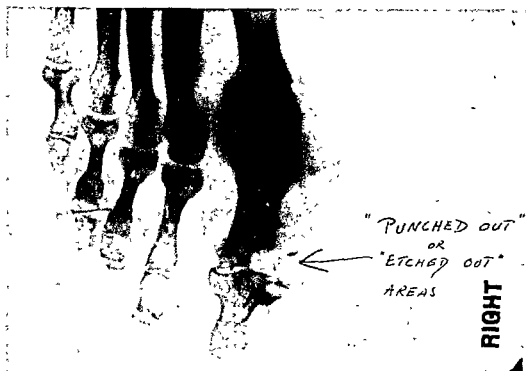


Fig. 54.—Gout. X-ray picture of joint of big toe.

in the joints, and on an average of twelve years (three to forty) after the first attack, the attacks become more frequent and when their activity subsides they leave a residual arthritis with stiffness, pain and deformity; tophi also occur in this final stage. With all due respect to Dr. Hench, and my respect for him is very great, this does not, in my experience, represent a complete and faithful picture. I am a subject of gout myself and have been for twenty years. About ten years ago Dr. Hench told me I was in the pre-tophaceous stage: but I have no tophi yet. Gout attracts gout, and I know about twenty men who, like myself, have had the disease for fifteen to twenty-five years; several of them are retired physicians and we sit and exchange experiences concerning our common enemy. Besides, my colleagues have for

years taken a grim delight in sending me their cases, especially their most horribly mutilated ones.

Of this group of my cronies of twenty or more years' experience, 25 per cent have developed tophi, about 25 per cent have residual joint changes, but only 10 per cent have joint changes sufficient to be crippling. For instance, I myself have an ankylosis of the left great toe when I had my first attack, but it does not interfere with my activities. Sixty per cent of these men have experienced a let-up in the severity of the attacks, or longer intervals between attacks, or both during the latter years.



Fig. 55.—Tophi in gout.

When tophi and deformity and disability appear, in my experience, they usually do so fairly early. The worst case of tophi I ever saw—with tophi in nose, ears, eyelids, fingers, and feet, with ulcerations at many joints so that whole phalanges had ulcerated out—was in the person of a farm boy, twenty years of age, who had never tasted an alcoholic beverage in his life, had always eaten rough fare, and had had the disease only two and a half years. I believe, in short, that Dr. Hench's classic gout occurs in only about 25 per cent of cases even if the subject lives long enough to be a candidate for it.

7. Hemophilia is much more likely to present to the clinician as an arthritis than as a "bleeding" patient. Whenever chronic disability and ankylosis affect a knee or ankle following slight injury, the disease should be suspected. In a consecutive series of 98 patients with hemophilia, arthritis occurred in 79 per cent (Thomas: *J. Bone and Joint Surg.* 18: 140, 1936); half of the patients developed permanent joint deformity.

In order of frequency the joints involved were knee (68 per cent), ankle (56 per cent), elbow (53 per cent), hip (16 per cent), fingers (15 per cent), wrist (5 per cent), spine (3 per cent), and toes (2 per cent).

The reason for the preponderance of knee and ankle injuries is that before the patient knows that he has the disease, he jumps from small heights (one of my patients was a butcher delivery boy who used to leap from his high seat and land stiff-legged), causing a hemorrhage into the joints.

The acute phase of hemophilic joints is simply a rapid effusion of blood into the joint surfaces. In the course of time this produces a hyperplasia of the joint membrane, deposit of blood in synovial tissues with formation of dense, fibrous connective tissue, erosion of cartilage at margins by synovial membrane and marked deformity, with muscular atrophy although bony ankylosis is practically unknown. Normal function may be restored after joint hemorrhage—in one case recorded 45 times.

8. Neuropathic joints—Charcot's joint. Charcot described changes in joints due to syringomyelia as well as tabes, so both are "Charcot joints." Every organ in the body depends for its normal metabolic function, not only on a good blood supply, but also on a good nerve supply. When proper nervous impulses are cut off, trophic changes begin.

Syringomyelic neuropathic arthritis is likely to occur more frequently in the upper extremity; tabetic arthropathy, in the lower. But any joint may be affected. The essential feature of either form is loss of sensation in the joint. A slight injury occurs and because of lack of pain, the patient continues to insult it. The synovial membrane is worn away, and there is overgrowth of chalky bone around the joint.

The Charcot arthropathy presents as a swollen and badly deformed joint which is usually covered with tortuous veins, and which, on account of bony destruction, may present hypermotility, in fact, dislocation with flaillike motion.

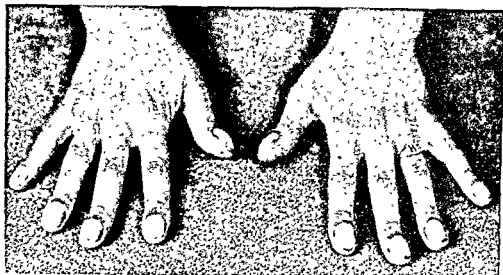
Hysterical joints may be very puzzling, imitating nearly anything, but with no real organic pathology.

9. Intermittent hydrarthrosis is a chronic condition in which at periodic intervals there is an effusion into joint cavities persisting for several days. The knees are most often affected and it is usually unilateral, but may be symmetrical. Pain is not prominent and there are no signs of local inflammation. Affected individuals usually have the first attack about the age of twenty to thirty and the attacks recur at intervals of a week to three weeks for an average of ten to twenty years and leave no permanent disability. Best guess as to cause is food allergy.

10. Disseminated lupus erythematosus in most instances presents as an acute polyarthritis with fever and leucopenia. The skin eruption follows. (See p. 193.)

11. Pulmonary osteo-arthropathy is a hypertrophic bone formation, usually of the terminal phalanges, evidenced by club fingers and rounded nails, which occurs in long-continued pulmonary suppuration—tuberculosis, lung

abscess, old undrained empyema, bronchiectasis with bronchitis. While usually confined to the ends of the fingers, I have seen cases in which nearly every joint in the body was involved.



A.



B.

Fig. 56.—Hippocratic fingers in bronchiectasis, showing marked return to normal appearance following treatment of the bronchiectasis. A, before treatment; B, after treatment.

Clubbed fingers with similar pathology also occur in congenital heart disease. Mendlowitz and Leslie (*Am. Heart J.* 24: No. 2, Aug., 1942) have been able experimentally to produce an anastomosis of the pulmonary artery

to the left auricle in dogs, which reproduces the conditions of congenital heart disease; in one animal hypertrophic osteo-arthropathy developed, apparently attributable to increased systemic blood flow.

13. Syphilitic Arthritis.—Clutton's joints.—The only notable syphilitic arthritis is that described by Clutton (*Lancet* 1: 391, 1886). It occurs most often in congenital syphilis, is seen up to the age of fifteen, and is usually a painless hydrarthrosis of both knees. Several types have been described; first, the common hydrarthrosis, and second, gummatous infiltration of the soft tissues, although Dennie and Pakula (*Congenital Syphilis*, 1940) doubt whether real gummata ever form.

Bursae.—The bursae most likely to become the seat of inflammation are, in the upper extremity, the subdeltoid and the olecranon and, in the lower extremity, the prepatellar and the bursae in the feet.

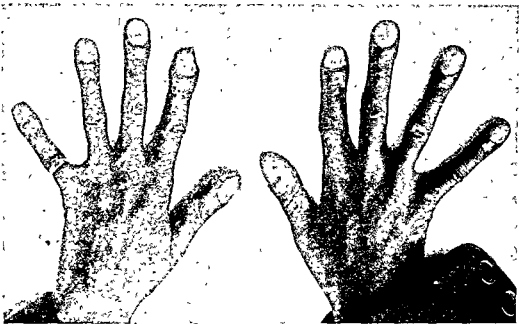


Fig. 57.—Clubbed fingers Congenital heart disease.

The subdeltoid, or subacromial, bursa lies over the supraspinatus muscle and under the deltoid, approximately over the humerus. Inflammation of this bursa is the commonest cause of pain in the shoulder region (80 per cent of all). The etiology of subdeltoid bursitis is trauma, usually just overuse of the arm, foci of infection, and metabolic disturbance.

The symptoms are pain in the shoulder joint, radiating into the neck, arm, forearm, and fingers, limitation of motion, tenderness over the greater tuberosity of the humerus. A history of exposure to cold is common. In a small proportion of cases there are calcium deposits in the bursa or in the insertions of the muscles around the bursa.

Syphilitic bursitis of the olecranon and prepatellar bursae, described by Verneuil (*Gaz. hebdom. de méd.* 39: 609, 1868), is a gummatous infiltration, usu-

ally symmetrical, which may break down with fungating ulcers and, when it heals, fistulous tracts (Lane. Syphilitic Bursitis, J. A. M. A. 82: No. 11, March 15, 1925), or become indurated and fibrous. In the olecranon, aside from trauma and inflammation from focal infection, the only thing that need be differentiated is gout, and this is more painful and not likely to be symmetrical. Gout also affects the prepatellar bursae, but the condition that needs differential diagnosis here is traumatic prepatellar bursitis (housemaid's knee).

Bones.—Diseases of the long bones of both extremities which the internist must consider are: (1) infections—osteomyelitis, tuberculosis, and syphilis, (2) tumors, (3) osteitis fibrosa cystica, (4) rickets, (5) osteomalacia, (6) scurvy, (7) osteitis deformans, (8) deformities.

1. **Osteomyelitis** affects the *long* bones in the following order of frequency: femur (43.4 per cent), tibia (38.7 per cent), humerus (9.6 per cent), fibula (3.5 per cent), radius (2.9 per cent), ulna (1.8 per cent). The short bones, as follows: metatarsals and phalanges (22.0 per cent), os calcis (17.3 per cent), metacarpals and phalanges (7.0 per cent), tarsus (4.4 per cent), astragalus (2.9 per cent), carpus (1.5 per cent). (Heinonen: Acta chir. Scandinav. 58: 289, 1925.)

Cases of osteomyelitis usually are seen by the internist, pediatrician, or general practitioner first rather than by the orthopedic surgeon under the diagnosis of "rheumatism" or "acute rheumatic fever," and it is astonishing how regularly the diagnosis is missed.

Most cases are due to staphylococcal infection, and in the majority it is a metastatic blood stream infection, the primary site of infection being the skin, parametrial tissue or sinuses.

The pathogenesis from skin infection should be emphasized. When a furuncle or carbuncle is present, the connection is obvious, but the slightest traumatism to the skin can be the focus.

I will not attempt to describe the pathology in detail. The abscess may form at the end of the medullary canal, so that the pain is referred to the joint, and the diagnosis of arthritis made. There is no credit in making a diagnosis of osteomyelitis after the bone is large and deformed, abscesses point, fistulae appear, and sequestra have formed. The obligation is to make it in the early stage.

Chronic forms of osteomyelitis, or at least bone infection, are rare. They include the "quiet necrosis" of Paget, Brodie's abscess and the sclerosing, nonsuppurative osteomyelitis of Garré. The internist is not likely to see these cases, and I refer to orthopedic treatises for description of them.

Tuberculosis of the bone, without joint involvement is mentioned only because it probably does not exist. The burden of proof, at least, is on the one who makes the diagnosis.

Syphilitic bone disease is very common in both congenital and acquired syphilis. Diagnostic error occurs so often as to constitute a professional reproach. Stokes reports that 21 per cent of such cases in his series were submitted to surgical interference without a diagnosis of syphilis having been made.

Periostitis in any long bone with dense bone growth should be regarded as suspicious.

The commonest bone lesions of syphilis are:

a. *Tibia*—saber shin.—In making the diagnosis, the Wassermann may be relied on to be positive in a very high proportion of cases, common rumor to the contrary. (Stokes says 82 per cent, Campbell says 90 per cent.) Associated cutaneous or visceral lesions, and in congenital syphilis, stigmata, are valuable hints. Stokes writes that active cutaneous lesions were in 43 per cent of his series of bone and joint syphilis, scars in 4 per cent, and genital scars in 11 per cent.

Saber tibia occurs in congenital and acquired forms. The essential pathogenesis is, first, a periostitis which lays down a dense layer of bone over the shaft of the tibia, producing a rounding on the anterior aspect. In the acquired form it appears as early as the secondary stage. In the congenital form it usually appears toward the end of the period of bone development—in adolescence or early adult life.

b. Cranial bone syphilis and spondylitis are common and described in their proper places.

c. The shoulder girdle (including the sternum and ribs) is often the seat of *gumma*. Suspect *gumma* in any swelling of the clavicle, either in the shaft or at sternal or scapular connections.

d. *Dactylitis syphilitica* affects either fingers or toes, but much more frequently, fingers.

Dactylitis syphilitica was given its first complete clinical description by R. W. Taylor (Am. J. Syph. and Derm., January, 1871). He stated that it was "a rare manifestation of syphilis in the deeper structures of the fingers and toes. This affection consists in the deposit of a peculiar gummy material of tertiary syphilis in one or all of the deep tissues and is characterized by peculiar deformities." In the congenital form it may occur in very young infants—six months. In the acquired form it is a tertiary manifestation. Taylor describes only one case in which a toe was involved: the second toe became larger in all aspects and rode above the big and third toe. In the hand the carpals and metacarpals are affected, seldom the terminal phalanges and usually only one bone. In classical examples it presents a characteristic picture of a cylindrical swelling, making the member larger than its fellows and often longer. Bony destruction, either gummatous breakdown or in the form of a complicating osteomyelitis, may take place with resulting deformities. X-ray plates may show either constructive or destructive bony change, as the case may be. The shaft of the affected bone is larger than its fellows. Differential diagnosis must consider a superficial infection, paronychia, and especially tuberculous dactylitis.

2. Tumors of bone may be: (1) metastatic, (2) periosteal fibrosarcoma, (3) osteogenic, benign or malignant, (4) benign giant celled, (5) angioma, benign and malignant, (6) Ewing's tumor, (7) myeloma.

Of benign osteogenic tumors, *osteoma* and *exostosis* may occur in any bone, but a special predilection for os calcis, knee, ankle, and end of femur may be

noted. *Chondromata* are especially likely to affect the fingers; they may be single or multiple. The *malignant osteogenic sarcoma* plays no favorites in its selection of a site. It is not the purpose or function of this book to describe these conditions in detail, merely to remind the diagnostician of their possible presence.

Benign giant cell tumors and bone cysts have a considerable predilection for the distal ends of the femurs and proximal ends of the tibiae.

Ewing's tumor, which he considered to be an endothelioma, is of interest because in its onset the constitutional reaction, with pain, fever, and leucocytosis, may suggest an infection and be labelled with the wastebasket title "rheumatism."

Myeloma, a tumor of bone marrow, is usually *multiple myeloma*, is a disease of adult life, usually of males, and in some part of its course is associated with toxemia, anemia, myelocytes in the blood and Bence-Jones albuminuria so that it may well be mistaken for a constitutional disease.

3. *Osteitis fibrosa cystica*, a manifestation of hyperparathyroidism, is described on p. 218.

4. *Rickets* is manifested in the extremities by deformities due to the molding of the softened bones. The lower extremities naturally receive most of these, since they bear the weight of the body, but the arms may be affected. Diagnosis should not be difficult because of the stigmata of rickets: bossing of the skull, failure of closure of fontanelles, rachitic rosary (beading at the junction of the ribs and cartilages), Harrison's groove and diffuse enlargement of the ends of the long bones.

5. *Osteomalacia* is a metabolic disorder in which calcium and phosphorus are not absorbed and consequently softening of bone takes place. In that respect, and also because the condition is always successfully treated with vitamin D, it resembles rickets and has been called adult rickets. It occurs during pregnancy, is endemic in Northern India due to hunger, rare in the United States, and usually associated with chronic steatorrhea. There is a mild and a severe form. In the mild form the complaints are only of weakness, pain in the bones of the leg and back on standing and walking. In the severe form the chief complaint may be the associated tetany. Or there may be pathologic fractures, or complete bedridden disability.

6. *Scurvy*.—The bone lesions of scurvy occur almost exclusively in the infantile form. They consist of hemorrhages under the periosteum of the long bones, most commonly over the lower end of the femur, upper end of the humerus, both ends of the tibia and costochondral junction of the middle ribs. Often the muscles are infiltrated with hemorrhage also and a classic sign is swelling between the Achilles tendon and the tibia. All of such areas are tender to pressure. The presence of other signs of scurvy, such as bleeding from the gums and subcutaneous ecchymoses, should make the diagnosis clear.

7. *Osteitis deformans*, *Paget's disease*, so-called because it was described by Sir James Paget in 1876, was considered by him to be a chronic inflammation of the bone. In its common and classical form it consists in hypertrophy and bowing of the long bones, particularly the tibiae and femurs, and of the

bones of the calvarium and spine, so the subject presents the appearance of a little, old, bowlegged, humpbacked man or woman with an enormous head. Monostatic or localized forms occur, affecting most commonly the ischium, pubis, ilium, sacrum, or a vertebra.

Sir James considered it a rarity, but time has shown that in one form or another it is very common. Schmal found post-mortem evidence of it in 3 per cent of persons over forty. I know of no reported case under the age of forty and most cases begin at the age of fifty, sixty, or seventy.

Other features of the disease are deafness, shrinkage in height, a waddling gait, and weakness, all secondary to the bony changes.

Pain is the symptom which most commonly brings the patient to the physician and it is important to remember that many cases are labeled and treated under the frayed designation of "chronic rheumatism." The course of the disease is variable, most cases becoming arrested. In a complete and classical case that goes on to the terminus so often depicted, it takes twenty to thirty years for the course to be finished.

The prevailing opinion today is that Paget's disease is due to a local disturbance of metabolism. Blood calcium is normal and blood phosphorus increased. Serum phosphatase is always increased quite markedly in most cases. Attempts to link it with parathyroid disease have not been successful, as the blood chemistry is different, nor do therapeutic results, either by parathyroidectomy or the use of parathyroid extract produce any good results: in fact, they do harm. The x-ray plate shows dense bone and loss of normal architecture. There is fuzziness of the surface of the skull bones and the involved long bones.

8. Deformities of Bone.—The hip is the site of many deformities, such as coxa vara, coxa valga, coxa planus, and Perthe's disease (flattening of the head of the femur), but since these are purely local, description of them is out of place in this book, and the student is referred to manuals of orthopedic surgery. The same applies to the varieties of clubfoot.

Hereditary deforming chondrodysplasia is a developmental disorder of growth, with multiple exostoses and irregularities in growth of the epiphyses. Arrest of growth in height and genu valgum and genu varum is secondary to these changes. The tumors are usually painless but may cause pressure on nerve trunks. Joint pains may result from articular distortions.

Diseases of the Muscles, Tendons and Fasciae of the Extremities.—Few of these are of general interest.

Myositis Ossificans.—There are three forms—myositis ossificans traumatica, myositis ossificans circumscripta, and myositis ossificans progressiva. The traumatic form presents a muscle infiltrated with bony tissue after injury. Living as I do in the heart of the football country, I have seen a good many cases: the highest incidence is in the thigh muscles of football players. The circumscribed form occurs with the formation of bone in a scar.

Myositis ossificans progressiva occurs without traumatic or surgical etiology. It is characterized by a slow proliferative inflammation with bone formation in muscles, tendons, and fasciae. It occurs most often in males and usually

starts before the age of ten years. Three stages are distinguished: first, swelling, edema, and hemorrhage into the muscles with fibroses but no skin involvement; second, contraction of the fibrous mass, throwing the muscles involved out of commission, and the skin may begin to be involved; third, bone deposits which are structurally and chemically the same as normal bone. The disease may exist for years without being recognized, manifested only by a little stiffness and limitation of function of the muscles. Any muscles may be involved, the neck and back somewhat more frequently than others. The overlying skin is red and edematous, and fever and local tenderness are present; then fibrous nodules appear. In the final stage the typical picture is that of the spine stiffened in the position of kyphosis, the scapulae are attached to the bony thorax by bridges of ossified bone, neck is anteflexed, and there may be ankylosis of the arms, legs, and jaw. Polydactylism, microdactylism, web toes, and short sacrum are congenital deformities which may accompany the disease. Diagnosis is not difficult in the later stages because the x-ray plate always shows the bony deposits in the muscles. In the early stages, it must be differentiated from dermatomyositis, scleroderma, and fibrositis.

Fibrosing Myositis.—As Hertzer well says, the muscles will react to any disease of the skin above or the bone beneath. The worst case of fibrosing myositis I ever saw occurred in the arm of a nurse following a smallpox vaccination. It may occur after rupture of a muscle sheath, or after aseptic operations on bones. The muscle bundles are replaced with fibrous tissue.

Dermatomyositis is a nonsuppurative inflammation of the skin, subcutaneous tissues, and muscles, of unknown etiology. The age incidence is from twenty to forty years. It begins either acutely with fever, prostration, muscular weakness and pain, or more frequently, in an insidious manner. The skin becomes firm, thickened, and edematous. The muscles are at first swollen and painful. Later, fibrous infiltration takes place and contractures develop.

Examination of the muscles show them to be pale yellow at first, filled with serum and semifluctuant or if the effusion is considerable, tense and firm.

The disease has protean symptomatology: dermatitis, with a dusky erythema that may resemble pellagra or Addison's disease; telangiectatic patches on the skin over the elbows and knuckles; α -characteristic facies, edema of the eyelids, splenomegaly, lymphadenopathy, eosinophilia, and abnormalities of creatine-creatinine excretion.

The eyelids may be affected before any other part of the body. The upper lids are swollen and colored a rose pink, which on close inspection is seen to be due to the presence of numerous telangiectases. The face is often covered with delicate rosy plaques, or numerous closely set telangiectatic areas. This leads to the typical facies: definitely swollen eyelids with narrowing of the lid spaces and a background of faint rosy or pale blue skin, by some called wine-colored and described as a heliotrope bloating by Keil (*Ann. Int. Med.* 16: No. 5, May, 1942). (See also Keil: *Dermatomyositis and Systemic Lupus Erythematosus: the Clinico-Pathologic Features*, *Arch. Int. Med.* 66: 339, 1940.)

Differential diagnosis must consider scleroderma and disseminated lupus erythematosus. Scleroderma is not accompanied by fever, and the trophic

ulcers of scleroderma are not seen in dermatomyositis. The skin manifestations of lupus erythematosus are not entirely similar in distribution or nature to those of dermatomyositis. A biopsy may be necessary to clear the diagnosis with certainty.

Volkman's contracture is a form of fibrosed myositis, the origin of which is due to thrombosis of the vessels rather than rupture due to tight bandaging. It occurs most often in the forearm following splinting for Colles's fracture.

Chronic infective tenosynovitis affects a wrist or both wrists simultaneously or in sequence most frequently. There is a fusiform swelling which is very painful and an elevation of temperature. It runs a course of several months to recovery. It affects persons past middle life most frequently. It is likely to be, but should not be confused with

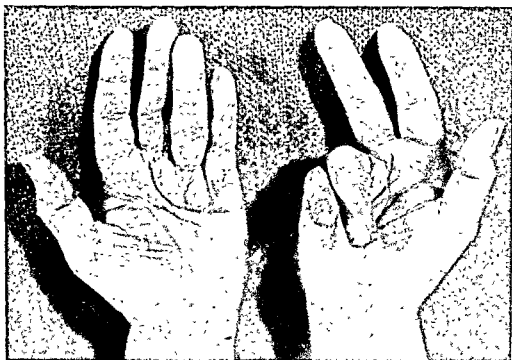


Fig. 58.—Dupuytren's contracture.

Tuberculous tenosynovitis, which affects the tendon sheaths in the region of the wrist and palm. It may begin above the lower ends of the radius and ulna or in the palm at the base of one of the fingers. The process is slower and there is a more gradual onset than in chronic infective tenosynovitis. Pulmonary involvement can usually be made out.

Ganglion is a cyst arising from a synovial sheath on the dorsum of either the hand or the foot. It presents as a smooth dome-shaped bulging, not painful or tender, save during the early period of formation.

Malignant tumors of fascia may occur anywhere. They are sarcoma, fibrosarcoma, myxosarcoma, giant cell sarcoma, and malignant lipoma. The last

often has a peculiar history. A tumor is removed which is shown to be histologically a lipoma: it recurs and recurs, and at each removal is seen to have more and more malignant cellular structure, going from lipoma to myxoma to sarcoma. (Thorek and Thorek: *Lipoma Pseudo-Myxomatodes of the Upper Extremity*, Arch. Surg. 28: 130, June, 1934.)

Dupuytren's contracture is a fibrosis of the palmar fascia of the hand, causing the fingers to contract toward the palm. It is of unknown etiology, the subjects being past middle age.

Lymph nodes, when enlarged in the groin, axillae, epitrochlear spaces, or anywhere on the extremities, are identified as such without difficulty in most instances, and have the same significance as they have elsewhere. They may represent infection in the nodes or distal to the node, or metastasis, lymphatic leucemia, or Hodgkin's disease.

Glanders, although extremely rare, should be mentioned as an example of enlargement of the lymph nodes, due to infection in the node itself—"farey bud."

The "*sattelite bubo*" of chancre affects the inguinal region, except in rare instances of chancre of the finger, when the epitrochlear or an axillary gland is involved.

Chancroid produces numerous enlarged inguinal lymph nodes which, in contrast to the syphilitic bubo, break down and suppurate.

Tuberculous adenitis is not common in the extremities except as an expression of miliary tuberculosis.

Tularemia involves the axillary nodes, which suppurate in about half the cases. Pain in the nodes often precedes, by about twenty-four hours, reference by the patient to the primary lesion.

Enlargement of the epitrochlear nodes without anything else to account for it, is a rough sign of generalized syphilis. It was so used in my student days before the advent of the Wassermann test.

Sarcoidosis, Boeck's sarcoid.—In Longcope's series the superficial lymph nodes were affected in 29 out of 200 cases. I saw a patient in which only the epitrochlears were involved, with large, smooth masses freely movable under the skin.

Fat pads are commonly lipomata. *Circumscribed symmetric lipomatosis* consists in unencapsulated masses of fat, most prominent in the neck and coming down over the arms. *Nodular multiple symmetrical encapsulated lipomatosis* is an hereditary disease; the nodules of fat are often painful and in this way are related to Dercum's disease. Menstrual disorders and rheumatic symptoms also occur. It affects both men and women. (Lyon: *Adiposis and Lipomatosis*, Arch. Int. Med. 6: 28, 1910.) *Adiposis dolorosa*, Dercum's disease, consists of localized fat pads found most frequently on the underside of the arms, occurring almost exclusively in women at the menopause. They are tender and painful and on palpation feel like a "caked breast" or "like a bundle of worms." They occur in subjects with a neuropathic personality.

Relapsing febrile nonsuppurative panniculitis (Weber-Christian's disease) is considered an infection with quite large swellings in the panniculus adiposus.

Nerves.—

Paralyses of peripheral origin in the extremities are:

Deltoid, due to injury or disease of the circumflex nerve.

Biceps is innervated by the musculocutaneous nerve, but is almost never paralyzed singly.

Wrist drop, due to paralysis of the muscles of the forearm, is innervated by the musculospiral or radial nerve. It is very vulnerable due to its course and possible involvement in fracture of the humerus.

Claw hand, due to paralysis of the flexors of the proximal phalanx, the lumbricalis and extensors of the distal phalanges, the interossei, is due to injury or disease of the ulnar nerve. There is likely to be associated anesthesia of the little finger and half the third finger. The thumb test may be applied to mild cases: when asked to grasp a thin object, such as a sheet of paper, the subject is not able to bring more than the tip of his thumb into approximation with the forefinger.

Quadriceps paralysis of the great muscles of the upper leg occurs from injury or disease of the anterior crural nerve.

Foot drop, from injury or disease of the peroneal nerve, is common in multiple neuritis, especially alcoholic. It also occurs in injury of the sciatic nerve when there is also atrophy of the leg and anesthesia of varying distribution. *Tremor of the extremities may be considered to be muscular or nervous.*

Muscular tremors are those of exophthalmic goiter, alcoholism, and nervousness from emotional shock. We may be permitted to hazard the guess that these manifestations are due to metabolic disturbance of the muscle. In exophthalmic goiter the muscle is charged with too rapid a metabolism to be still. In nervous shock there is too much epinephrine in the system. Alcoholism is probably a combination of both.

Tremor due to paralysis agitans, multiple sclerosis, encephalitis, paresis, hemiplegia, are plainly central, probably always a lesion in the corpora striata. Senile tremor I take to have the same origin, even though lesions cannot be readily demonstrated.

Trophic changes include ulcerations and auto-amputations of nervous origin: hemiatrophy and hemihypertrophy of one limb or one side, presumably due to congenital maldevelopment of one side of the brain; glossy skin as seen in old cases of peripheral neuritis and rheumatoid arthritis.

Trophic ulcers are found in *tabes dorsalis*, *spina bifida*, and *syringomyelia*. Because the syringomyelic patient may have areas of anesthesia to pain, injuries or burns may be received and be extensive before he realizes it: this often leads to the painless whitlow called

Morvan's disease.—In certain cases of syringomyelia there is associated peripheral vascular disease which produces a condition that has been called *status dysraphicus* (dysraphia—incomplete closure of the primary neural tube). The syringomyelia is familial and is either not progressive or very slowly progressive. Besides the trophic disorders, the affected individuals are likely

to have a number of developmental abnormalities, among them syndactylism of the toes, cleft arches of one or more vertebrae, abnormal skin reflexes of the abdomen, club feet, hypertrichosis.

The trophic changes consist in a ready tendency to ulceration of the toes and fingers upon trivial injury or infection, osteoporosis and sloughing of terminal phalanges, particularly of the toes. (See Bremer: *Status Dysraphicus*, *Deutsche Ztschr. f. Nervenhe.* 95: 103, 1926; and Mulvey and Riely: *Familial Syringomyelia and Status Dysraphicus*, *Ann. Int. Med.* 16: No. 5, May, 1942.)

Morvan (*Gaz. hebdomadaire de médecine*, 1883) described the spinal form which goes by his name thus: "Paresis with analgesia of the upper extremities first limited to one side, then going to the other, ending always in one or more severe paronitis." (Paronitis—whitlow, felon, paronychia.)

Ulcerations, besides the trophic variety (see above), may be: (1) *infectious*—chancre on the finger constitutes 5.9 per cent of extragenital chancres, on the palm, 1.5 per cent according to Wile and Holman's figures. Finger chancre is particularly an occupational disease of gynecologists, dentists, and pharyngologists, who enucleate the tonsils with the forefinger. Tularemia, sporotrichosis, leprosy (really trophic), glanders; (2) *circulatory*—arteriosclerosis, diabetes, thromboangiitis obliterans, Raynaud's disease, scleroderma, varicose veins, erythema induratum (see below); (3) *malignant*—melanoma, rodent ulcer, etc.

Subcutaneous Nodes.—Neurofibromatosis is not likely to present any diagnostic difficulty. *Rheumatic nodules* occur along the tendon sheaths of the wrist and fingers, over the elbows and knees; they are hard and only rarely painful. Subcutaneous nodules also occur in rheumatoid arthritis. They vary in size from scarcely palpable, seedlike bodies to excrescences the size of olives. They are most common on the dorsal surface of the forearm, but may be observed over the olecranon and patella. They are never painful, are discrete and movable, the attachment being to the tendons and fascia rather than the skin. (Dawson and Boots: *Subcutaneous Nodules in Rheumatoid Arthritis*, *J. A. M. A.* 95: No. 25, Dec. 20, 1930.) *Erythema nodosum* are red, painful lumps which appear with great suddenness over the flexor surfaces of the forearms and lower legs; they do not suppurate and go away within a few weeks. *Peliosis rheumatica* (purpura rheumatica, Schonlein's disease) may resemble erythema nodosum. *Haygarth's nodosities* are really not nodes in the sense of those we are here describing. They are swellings around joints, especially the fingers in rheumatoid arthritis. Haygarth's (*Clinical History of Diseases: Part First, Being a Clinical History of Rheumatism and Nodosity of the Joints, 1805*) description is: "In this disease the ends of the bones, capsules or ligaments which form the joint gradually increase. The nodes are not separate tumors but feel as if they were an enlargement of the bones themselves." *Erythema induratum* appears in women of middle age, with poor peripheral circulation; the nodules are fairly deep-seated and painful. They frequently ulcerate. Some authorities regard this as a form of tuberculosis.

Heberden's Nodes.—"What are these little, hard knobs frequently seen on the fingers?" asked William Heberden, and would not stay for an answer.

Nor have many of his successors. They are just what he said they were—little, hard knobs on the fingers—and orthodox opinion relates them to osteoarthritis, although surely they occur in the absence of osteoarthritis. Age is a definite etiologic factor. Stecher (New England J. Med. 222: 300, Feb. 22, 1940) reported their incidence before the age of fifty as small, but afterwards it increases rapidly so that in 6 to 20 per cent of elderly white men they are present and in 20 to 30 per cent of elderly white women. They are about half as common in Negroes. When they first make their appearance, they are painful and tender, but as time goes on they lose these characteristics.



Fig. 59.—*Erythema nodosum*.

Osler's nodes are small, painful lumps in the pulp of the finger tips, found in subacute endocarditis. The patient can often feel them better than the examiner.

The Nails.—Diseases and deformities of the nails are given more prominence in some texts on physical diagnosis than they deserve. Most nail affections are local, due to ringworm infection, pyogenic paronychia, or trauma to the nail bed.

Color changes in the nails include white spots (leuconychia), which have no significance, and rarely striations, which are indicative of acute or chronic arsenic poisoning; pigmentation shared with the skin in Addison's disease; blue discoloration in argyria, and black in mercury poisoning.

Hemorrhages under the nail may occur in scurvy and hemophilia. Petechial splinter hemorrhages occur in subacute bacterial endocarditis and trichiniasis; in the latter they are said to occur in as high as 50 to 70 per cent of cases and may be the only reliable hint as to the nature of the condition.

Striations.—In any serious systemic disease the nutrition of the nail bed suffers and as the nail grows out, a transverse striation, depression, or thinning can be seen (Beau's lines). The date and length of a previous illness can often be determined by this. In the presence of this sign I have also found that if a hair of the head be pulled out, a beaded or thinned area can be made out with a hand glass, at an appropriate distance from the root: often in attempting to pull the hair out it breaks at this point. *Longitudinal* striations are due to variations in the conformity of the nail bed, and when not due to injury, are hereditary.

Atrophy of the nails is an hereditary trait, or in the toe nails, a result of the wearing of shoes: the nails of the little toes of civilized persons constantly show this atrophy.

Hypertrophy of one or more nails accompanies eczema and psoriasis, or endocrine dysfunction, particularly acromegaly, or injury. In the toenails the hypertrophy known as *onychogryposis* is sufficiently suggestive to indicate the help of a Wassermann.

Hippocratic fingers, clubbed fingers, go with chronic pulmonary osteoarthropathy (chronic pulmonary infection) and congenital heart disease and are accompanied by nails that have a gentle, domelike curve in all directions. They are also slightly cyanotic. Slight degrees of this condition can be made out in the early stages of bronchiectasis and are an indication for treatment of the nasal sinuses. Clubbed fingers may develop very rapidly, within six weeks, as seen in instances where the development began after an artificial pneumothorax.

Blood Vessels.—

Aneurysm of the popliteal artery is the commonest aneurysm of the peripheral arteries, making up about 50 per cent of the total. Femoral and femoro-iliac is next in frequency, carotid next, and axillary aneurysm is a rare occurrence.

Embolism is particularly likely to affect the arteries of the extremities. *Mitral stenosis*, auricular fibrillation and subacute bacterial endocarditis are common causes. Pain of great intensity marks the movement of embolic lodgement. In multiple embolism one may expect to find simultaneously, or in rapid succession, gangrene of an extremity, sudden blindness from retinal embolism, cerebral signs, hematuria, and hemoptysis. Symmetrical gangrene of the feet or toes occurs when an embolus lodges at the bifurcation of the aorta, finally breaking, with one part going down and lodging in one popliteal artery, the other part in the other artery. Saland (Ann. Int. Med. 14: No. 11, May, 1941) found heart disease as the underlying condition in 100 per cent of 12 consecutive cases of embolism.

Routine of Examination and Interpretation of Symptoms and Signs in Peripheral Vascular Disease

Pain, when due to peripheral vascular disease, means, usually, arterial deficiency. If it is precipitated by exercise and disappears on rest, causes the patient to limp or rest (intermittent claudication), it is due to arteriosclerosis or thrombo-angiitis obliterans. It may be the first symptom of such conditions. Sudden acute pain is indicative of sudden arterial closure

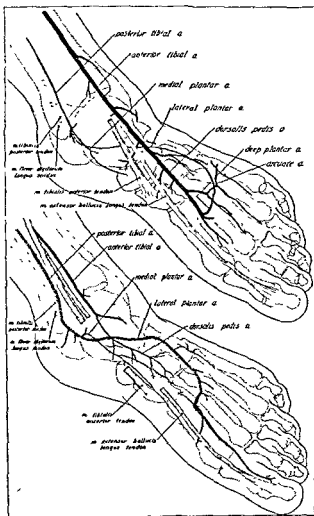


Fig. 60.—Dorsalis pedis artery, course and variation. (From Edwards: Chronic Organic Arterial Disease, New England J. Med. 221: No. 7, 1939.)

from thrombosis or embolism. There are associated absence of the peripheral pulses, coldness, local paralysis, pallor like that of a dead limb, and slight edema. Venous thrombosis—phlegmasia alba dolens—often begins with an acute pain on the inner surface of the thigh, the back of the knee or calf, due to ischemia from reflex arterial spasm. Persistent, continuous pain, associated with slight cyanosis and shiny skin, made worse by elevation and better by

depression of the foot, is indicative of serious arterial deficiency. Diabetic gangrene is curiously painless in most cases.

Coldness and pallor indicate constricted vessels, *cyanosis* indicates a slow current, whether the cause lies in the arteries or veins. Rapid onset of these signs in young people in response to cold or emotional upsets points to Raynaud's disease or similar syndromes. Sudden onset in those of middle age indicates arterial occlusion. When the onset of arterial occlusion is gradual, the limb gradually dries up. When it comes on suddenly, the blood in the capillaries is trapped, is not pushed on by the circulation behind, and as it stagnates, it loses its oxygen even while the leg is still warm, and there is cyanosis. If the limb be elevated and pressure is made sufficient to blanch a spot, it should be observed whether this spot regains its color: if it does, it may be concluded that some circulation is still going on. This test does not apply to the unelevated limb, because under such conditions the stagnant blood flows back and fills the vessels at the blanched spot. These phenomena may occur without accompanying pain, but even so they have the same significance.

Chronic cyanosis and coldness of the hands and feet in young people are probably due to continuous sympathetic irritability; in the elderly, to arteriosclerosis.

Peripheral Arterial Pulsation.—The *dorsalis pedis artery* is used as the standard for determining the state of the peripheral vessels of the leg. Its pulsations can be palpated on the top of the instep, to the inside of the first metatarsal bone and two to four fingers proximal to the distal head of that bone. Anomalies of distribution and size occur in the *dorsalis pedis*, as indicated in the diagram Dr. Edward A. Edwards herewith reproduced (Fig. 60). Writes Dr. Edwards: "The posterior tibial (artery) can be palpated just below and behind the medial malleolus. The importance of this vessel is not sufficiently appreciated. Let it be remembered that a substantial number of people are born with a small or absent *dorsalis pedis* artery. In such cases the posterior tibial will be large and will compensate for the absence of the former artery. An absent *dorsalis pedis* pulsation therefore does not necessarily indicate disease. However, since the anomaly is usually symmetric, the absence of a single *dorsalis pedis*, or a single posterior tibial pulsation is more likely to be due to disease than anatomical variation." (Edwards: *Chronic Organic Arterial Disease*, New England J. Med. 221: No. 7, Aug. 17, 1939.) In arteriosclerosis obliterans or thrombo-angiitis obliterans, if the *dorsalis pedis* pulsation is absent, the posterior tibial pulsation will also be absent.

The popliteal artery is best palpated with the patient prone and the leg flexed by the examiner's hand.

In the upper limb the examiner must palpate the axillary, brachial, radial and ulnar arteries, but obliterative arterial disease in the arm is practically nonexistent compared to the feet and legs.

DISEASES OF THE VEINS

Thrombophlebitis.—The commonest form is *femoro-iliac thrombophlebitis* or *phlegmasia alba dolens* or *milk leg*, which occurs as a complication of pelvic

inflammation, appendicitis, the puerperium, surgical operations, whether in the pelvis or not, and certain infectious diseases, notably typhoid. The most important single factor seems to be that the subject is hospitalized in bed. Only very rarely does this occur to an individual in the midst of activity.

The essential feature of the condition is thrombus formation. We need not discuss the classical causes of thrombus formation, but concentrate on the fact that blood platelets in some way get attached to the wall of the vein and form a clot, obstructing the vein. When such a vein is opened, the usual picture of the completed clot is a short proximal head which is white, an intermediate portion which is mixed white and red, and a tail which may be very long and makes up the largest part of the thrombus. The head, or white part of the thrombus, is made up of dead platelets and leucocytes. The red tail is an ordinary clot and is secondary and incidental.

If the white head becomes sufficiently organized to occlude the vessel, all may be well; but if part of the lower thrombus gets by, or if a continued propagation of a thrombus centrally from the white head occurs, pulmonary embolism and infarction may result. This is the real significance of the condition. It is the cause of the sudden death from pulmonary embolism following surgical operation. Of course, as the researches of Homans and Leriche (Bull. et mém. Soc. nat. de chir. 53: 561, 1927) show, pulmonary embolism probably occurs more frequently as a result of an unnoticed thrombosis anywhere in the body than with outspoken *phlegmasia alba dolens*.

Deep peripheral thrombophlebitis, thrombosis of the deep veins of the lower leg, is a condition described by Homans (New England J. Med. 221: 993, Nov. 29, 1934). It occurs during active life; the cause may be a trivial or minor injury below the knee, a strain, a fracture of one of the bones of the foot, or a complication of a respiratory infection or rheumatic condition. The veins involved are those in the calf muscles. The symptoms are lameness, not marked, with swelling of the ankle and foot, perhaps a little cyanosis. Tenderness is not present, even on deep pressure on the calf. A pathognomonic sign, according to Homans, is a sense of discomfort experienced by the patient when the tendo Achilles is put on the stretch by forced dorsiflexion of the foot. Here again the importance of the condition is the very likely chance of pulmonary embolism.

Thrombosis in varicose veins frequently occurs, but seldom results in pulmonary embolism. Homans has record of only two cases.

Phlebitis migrans occurs in patients with Buerger's disease, and also in subjects without Buerger's disease and without varicose veins. In Buerger's disease the phlebitis is most likely to occur in the upper extremities: a vein on the back of the hand becomes painful and sore to the touch; in the course of a week or two, the soreness disappears, but a new stretch of vein central to, but not continuous with the first one, or a vein on the opposite hand or arm is attacked. In nonvaricose superficial veins of the legs the same thing may occur, not in the presence of Buerger's disease. These do not often cause pulmonary embolism. (See Conner: Thrombophlebitis and Its Pulmonary Complications, New England J. Med. 22: No. 4, Jan. 25, 1940; and Ochsner: New England J. Med. 225: 207, 1941.)

Thrombosis of the subclavian and axillary veins is a rare condition although Veal and Hussey (*Am. Heart J.* 25: 355, March, 1943) have reported 46 cases under their own observation. The common cause is stasis from heart disease (hypertensive, syphilitic, and rheumatic). Infection, trauma, and adjacent neoplasm also operate. The thrombosis may come on suddenly or gradually. Acute onset is heralded by pain from shoulder to hand. Vasospasm causes cyanosis and coldness of the fingers. Within a short time the hand and arm swell to as much as twice the natural size. The systolic blood pressure is 10-15 mm. higher on the affected side.

Gradual occlusion begins with slight enlargement and fatigability of the affected arm. Vigorous or prolonged use of the arm brings on increased swelling and such fatigue that continued use of the arm is impossible. Soon the collateral circulation can be seen with enlargement of veins of the upper arm, shoulder, and chest.

Prognosis in the cases of cardiac disease is not invariably bad, but pulmonary embolism is frequent.

Varicose veins are definite handicaps to efficiency. Therein lies their only interest to the internist. Varicose veins have lost their power to transmit blood toward the heart, partly from more or less destruction of their valves, partly from intrinsic disease of the vein wall. They are practically confined to the lower extremity. Neither in etiology nor in their complications are they related to general systemic disease. The various tests that are used on varicose veins—Trendelenburg's, Schwartz's, Perthe's—are designed simply to allow surgeons to determine the advisability and method of operation, so we need not burden this treatise with their description. (See McCallig and Heyerdale: *A Basic Understanding of Varicose Veins*, *J. A. M. A.* 115: No. 2, July 13, 1940.)

DISEASES OF THE PERIPHERAL ARTERIES: ROUTINE STUDY FOR A PATIENT WITH PERIPHERAL VASCULAR DISEASE

1. History—duration of symptoms; when intermittent claudication began; when ulceration began. Date and character of injury, if any. Degree of pain, i.e., constant, at night only, on change of position, use. Effect of cold, heat, dependency, elevation, exercise.
2. Extent of infection, lymphangitis, ulceration, gangrene.
3. Description of surface lesion.
4. Volume of pulse in vessels—one plus to four plus.
5. Length of time for blanching to occur on elevation, cyanosis on dependency.
6. Surface temperature of extremities.
7. Oscillometer readings.
8. X-ray examination of vessels of extremities.
9. Blood sugar and urine sugar.

Arteriosclerosis is the commonest cause of circulatory deficiency in the extremities. The process consists of a progressive thickening of the subinti-

mal tissues, which gradually encroach on the lumen of the vessel, terminating in obliteration (partial or complete), arteriosclerosis obliterans, endarteritis obliterans. The subintimal thickening grows out from one side of the vessel. Coincidental with, or perhaps following, the intimal proliferation, there are degenerative changes in the medial coat, followed by atheroma and calcareous deposits. The process is patchy. Thrombosis may occur, as can be readily appreciated: the scene is all set. There is a decided tendency for the process to affect the legs, the arms being rarely affected.

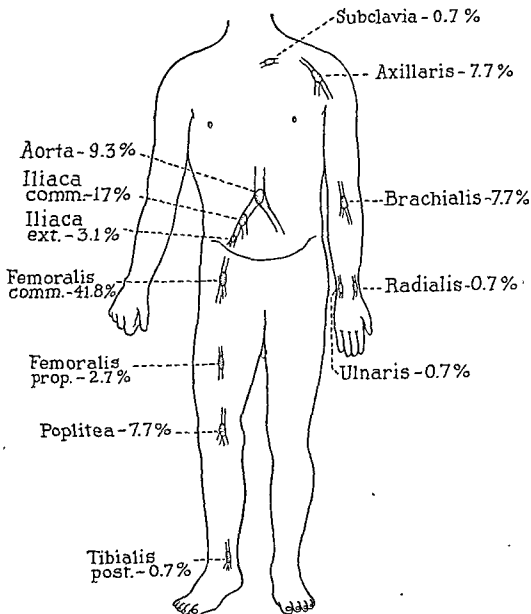


Fig. 61.—Frequency of embolism in different peripheral arteries. (After Peyton: *Ann. Int. Med.*)

The process is bilateral, although the development is usually unequal: the signs of circulatory insufficiency are more noticeable in one leg than the other.

Of contributing factors, age is the most important. Infection, focal or other, probably has little influence. Males predominate. Diabetes has a most evil effect: gangrene is four times as frequent in the arteriosclerotic diabetic as in the nondiabetic arteriosclerotic.

Hypertension, diastolic value of 90 mm. or more, systolic of 150 mm. or more is present in 35 per cent of the cases.

Absence of pulsations in the posterior tibial, dorsalis pedis, and popliteal arteries is the rule and in many cases pulsations are absent in the femoral artery in Scarpa's triangle. Pallor of the extremities on elevation and excessive rubor on dependency are valuable signs of arterial insufficiency, as is delay of color on dependency after elevation.

The end result of this process will depend upon circumstances. Complete obstruction may never occur, or collateral circulation may keep pace with it sufficiently that no symptoms except cold extremities and muscular weakness occur. When the collateral circulation is not quite sufficient and lags behind the obstruction, intermittent claudication and trophic disturbances of the skin and nails will come on and last a long time "without any serious disability," as Dr. Homans says. If the occlusion becomes complete without adequate collateral circulation, or if the occlusion is sudden by a superimposed thrombosis, gangrene is practically inevitable.

When the occlusive process is in the upper part of the femoral artery or in the iliac arteries, ischemic neuritis may develop. It is paroxysmal, the pain involving most of the leg and foot. The paroxysms are worse at night. Vaso-spastic color changes and sometimes petechiae occur in the skin. Arteriosclerosis obliterans. (See Hines and Barker: *Am. J. M. Sc.* 200: 722, Dec., 1940.)

Intermittent claudication is a cramp or pain in the muscles, particularly of the calves of the legs, during walking. The subject always has to stop and rest. After a few minutes the limb is comfortable again. The mechanism is undoubtedly onset of ischemia, due to narrow and inadequate arteries. Not only the mechanism, but also the sensation is the same as an anginal attack. One of Dr. Christian's patients told him, "There is no difference in the sensation, only in the place." Tobacco, as in other similar conditions, is a precipitating factor.

Gangrene.—

Gangrene of the upper extremity may be caused by: Raynaud's disease, obliterative endarteritis, thromboangiitis obliterans, embolism or thrombosis, chemical agents, frost bite. Gangrene of the upper extremity or fingers is a rare occurrence.

Gangrene of the lower extremity may be due to all the causes given for the upper extremity and also gas gangrene, ergotism, chemical (phenol), popliteal aneurysm, purpura fulminans, and painum.

We shall not consider those of traumatic, chemical, or physical (frostbite) origin.

Diabetic gangrene is due to the underlying arteriosclerosis obliterans. It is the same process which causes the atrophy of the islets of Langerhans and the retinitis. The diabetic state is not the cause, although it seems to predispose to gangrene.

The average age of the patients in McKittrick's series (McKittrick: Arch. Surg. 40: 354, Feb., 1944) was 64.3 years. They had had diabetes for an average of eight and seven-tenths years. In 70 out of 972 cases the gangrene was bilateral. The immediate mortality from operations was 13.9 per cent. After amputation of one foot, gangrene occurred in the other foot in 41 per cent of cases. The average postoperative duration of life was forty-five and a half months. In those who refused operation, 33 in all, 20 died of progressive gangrene or after amputation elsewhere, 11 survived later amputation, one had gradual healing, and died four years later of coronary thrombosis, one had slow healing, but has never been able to walk on his foot.

Gangrene due to embolism is especially associated with mitral stenosis. Otherwise any cause of embolism—infection, arteriosclerosis—may be the cause. It may localize in any part of the foot—not necessarily in the toes.

Gas gangrene is due to infection with the *Clostridium welchii* or *aerogenous capsulatus*. The history is of an accident with destruction of the skin and the parts contaminated with clothing. Fever appears early, the temperature reaching 106° F. Pain is intense. Crepitation of the skin is noticed early. There is a high leucocytosis (28,000 to 90,000). The gangrene is usually extensive and spreads rapidly.

Ergotism may occur from full therapeutic doses of ergot and ergotamine tartrate. It usually affects all the toes of both feet.

Thrombo-angiitis Obliterans—Buerger's Disease.—Buerger (Am. J. M. Sc. 136: 567, Oct., 1908) wrote that this is "an inflammatory lesion with occlusive thrombosis, and that it affects the arteries and veins in a kind of relapsing fashion." It is characteristic that it comes on in attacks during which new groups of blood vessels are affected. The inflammation consists of a proliferation of the intima, containing multinucleated giant cells, histiocytes, lymphocytes, and polymorphonuclear leucocytes. The media and adventitia also show inflammatory exudate of acute and chronic character. The crucial lesion is thrombosis.

Men are affected almost exclusively. The age of onset is much younger than in arteriosclerosis, being in the late twenties, thirties, and forties. The upper extremity is more often affected than in arteriosclerosis. No etiology is known, though tobacco is prominent among the factors accused. Formerly supposed to occur only in those of Jewish race, it has since been described in persons of all races.

The clinical types have been mentioned as (1) acute fulminating; (2) non-progressive; (3) slowly progressive, and (4) compensated or healed. Pain on walking (claudication) is the first symptom in about 51 per cent of cases. Coldness of the extremities in 12 per cent, abnormal fatigue in 11 per cent,

sudden arterial occlusion in 7 per cent, nonhealing ulcer in 10 per cent, recurrent superficial phlebitis in 4 per cent (consisting of the appearance of tender, red elevated spots about 1 cm. in diameter, which appear suddenly in the skin near the valves of superficial veins of the foot or lower leg, gradually disappear, in a few weeks, only to be replaced by new ones in different locations), edema in 3 per cent, and spastic vasomotor disturbances in 2 per cent. Gangrene and spontaneous amputation of a toe is a terminal event in from 20 to 40 per cent of cases, the difference appearing to be largely due to whether treatment is faithfully followed. It is an essentially chronic disease, the period between onset of symptoms and gangrene being on the average fifteen years.

The aching pain in the toes (or fingers), instep, and ankle may lead to the use of arch supports and other orthopedic appliances. Ulcerations follow trivial traumata, excessive heat, or local medication. Ill-advised chiropody for ingrowing toenail has often been followed by ulceration.

Brown (of the Mayo Clinic) vasomotor test in Buerger's disease—for the selection of those cases suitable for operation: Nonspecific protein fever is induced by giving 50 millions of triple typhoid vaccine intravenously, the oral temperature and skin temperature of the affected limb having been previously determined. In cases where there is great spasm of the collateral circulation of the affected limb there will be considerable rise in its temperature owing to disappearance of spasm due to the induced fever. The difference in surface temperature previous to and as a result of the fever is noted and from this is subtracted the rise in the oral temperature. The difference in degrees represents the rise in the skin temperature consequent on removal of the spasm. This surface increase divided by the number of degrees rise in the oral temperature gives the vasomotor index. As an example—the mouth temperature rises 2° C., that of the left great toe rises 13° C.: subtracting 2° C. gives the figure 11. The vasomotor index is, therefore, $11 \div 2 = 5.5$. In Raynaud's disease the index is high—5 to 14. In Buerger's disease it varies from 2 to 6. The higher the index the more sure the indication for operation and the better the prognosis. An index of zero or only slightly more is a contraindication for operation. (See McGregor: *A Symposium of Surgical Anatomy*, Williams and Wilkins, 1939.)

Raynaud's disease heads the list of spastic arterial diseases of the extremities.

Raynaud, in his original thesis (*De l'asphyxie locale et de la gangrène symétrique des extrémités*—Paris, 1862) wrote: "I propose to demonstrate a variety of dry gangrene affecting the extremities which cannot be explained by vascular obliteration, a variety characterized by a remarkable tendency to symmetry. I shall try to show that this kind of gangrene has its origin in a defective innervation of the capillary vessels. Local syncope is a condition perfectly compatible with health. Persons who are attacked with it under the least stimulus, sometimes without appreciable cause, have many fingers become pale and cold at once. The duration is from a few minutes to many hours. The determining cause is often cold; sometimes even a simple mental emotion is enough. The first symptom to attract attention is pain. Later the cutaneous sensibility becomes blunted:

the fingers become like foreign bodies to the subject: it is the phenomenon known as dead finger. There is noted an excessive feebleness of the pulse. The nose and external ears are sometimes attacked. The malady may follow a continuous course or be prolonged over a considerable time with periods of intermission. Symmetrical gangrene is most often imposed on those with a regular course."

Numerous studies made on the arteries, the skin capillaries, and the sympathetic nerves since Raynaud's time have tended to modify somewhat his original description. During an attack in the prethrophic stage, the skin goes through several changes: it is at first cyanotic, due to contraction of the digital, plantar, or palmar arteries. When pallor occurs, it is due to contraction of the skin capillaries. The final stage is that of hyperemia, a relaxation of the spasm, with dilatation of the capillaries. Circulation then remains until the next attack. (See Brown: Skin Capillaries in Raynaud's Disease, Arch. Int. Med. 35: No. 1, Jan., 1935.)

In the first period of purely spastic attack the arteries are histologically normal. As time goes on, in a certain proportion of the cases, the intima is thickened and the muscular coat of the arteries hypertrophied. At this time local gangrene, which is nearly always limited to the skin, appears. Approximately one-third of the cases are progressive.

Females predominate ten to one. The upper extremity—fingers and hands—are twice as often affected as the lower. The changes are symmetric in about 60 per cent. Average age at onset is between 18 and 30.

Differential diagnosis between arteriosclerotic disease and Buerger's disease should not be difficult if age, sex, symmetry, and upper limbs be remembered. The age of arteriosclerosis is definitely twenty years ahead of that in Raynaud's disease. The lower limbs are predominantly affected in arteriosclerosis and Buerger's disease; upper limbs, in Raynaud's disease. Young males have Buerger's disease; young females, Raynaud's disease. In neither arteriosclerosis nor Buerger's disease is exact symmetry likely. Of course, all cases are not classical and sometimes all signs fail.

Acrocyanosis is a blueness of an acral part, always an extremity, bilateral, the feet more than the hands, due to arteriospasm. It occurs in young women with a tendency to hysteria. In mild forms it is quite common, in severe forms, rare. Chronic ulcers, appear; they are very chronic and difficult to cure. Lumbar sympathectomy is successful in resistant cases.

Livedo reticularis is a mottled, blotchy or reticular, bluish discoloration of the skin predominantly affecting the legs and feet, with organic changes in the arterioles of the skin and chronic vasospasm. It has been divided into subforms, (1) *Cutis marmorata*, mottling on exposure to cold, disappearing on application of heat, (2) *livedo reticularis idiopathica*, in which the mottling is more intense and persists during temperature changes: occurs mostly in children with many congenital defects, (3) *livedo reticularis symptomatica*, in which the mottling is also persistent, and in which there is evidence of other disease of the cutaneous and subcutaneous vascular system: comes on in adult life. (See Barker, Hines, and Craig: *Livedo Reticularis*, Am. Heart J. 21: 592, May, 1941.)

Erythromelalgia—"red painful members" due to vasodilatation. It was first described by S. Weir Mitchell (*Am. J. M. Sc.* 76: 17, 1878) as follows: "Pain is throbbing, aching and burning. The striking peculiarity is the flushing of the part on exertion, greatest in the soles, marked by a dull, dusky, mottled redness, brought on by allowing the feet to hang down. The foot gets redder and redder, the veins stand out in a few minutes, as if a ligature had been placed around the limb, and the arteries throb violently until at length the extremity becomes dark purplish." It is the opposite of Raynaud's disease in that not only is there vasodilatation instead of spasm, but the symptoms appear in response to heat rather than cold. The subjects are likely to be males, past middle age. It is an extremely rare condition. Some of Mitchell's cases were due to bullet wounds of the nerves. Brown (*Erythromelalgia and Other Disturbances of the Extremities Accompanied by Vasodilatation and Burning*, *Am. J. M. Sc.* 183: No. 4, April, 1932) sets up four diagnostic criteria: (1) bilateral burning pain in the extremities; (2) sharp increase of local heat in the affected parts, but redness, flushing or congestion may vary in degree; (3) production and aggravation of the distress by heat and exercise; (4) relief by cold, rest, and elevation.



FIG. 62.—Scleroderma.

Scleroderma is a syndrome characterized by induration, pigmentation, and sclerosis of the skin of the extremities and face, associated with arthritis, asthenia, and loss of weight. Trophic ulcers eventually appear on the tips of the fingers. The results of surgical therapy—sympathectomy—seem to indicate that it is essentially a peripheral vascular disease. It is often associated with Raynaud's disease. The condition of the skin capillaries indicates a great reduction in the circulating capillary blood in the skin. There is a diminution in their number and the outlines are frayed, irregular, and indistinct. Histologically, the skin shows hypertrophy of the collagen, comparative absence of

blood vessels, large numbers of dilated lymph spaces, hyperpigmentation both in the rete and the corium and comparative absence of the glands of the skin.

No age is exempt, though middle aged females are in the majority. The course is insidious, beginning with arthralgia. The skin at the height of the process is of a peculiar, unresilient hardness and immobility, and this seems to involve the muscles. The hands and forearms are most often affected (sclerodactylia) and the gauntlet of skin may cause great disability, making finer movements impossible. The feet and nose and cheeks and forehead may also be affected. In the final stage small ulcerations appear at the ends of the fingers. Very rarely, so far as I know, there is auto-amputation of the terminal phalanges.

Aneurysm of the axillary artery is almost as frequent as aneurysm of the innominate (3 per cent of all aneurysms). Traumatic etiology is more frequent than syphilitic or mycotic. The symptoms and signs are pulsatile swelling in the axilla with pulsations corresponding to the apex beat, delay in the radial pulse (this is not constant), edema of the extremity, and weakness or paresis from pressure on the median, radial, or ulnar nerves. (Horsley: J. A. M. A. 35: 189, July 18, 1925. MacNealy and Spivaek: S. Clin. North America 5: 1095, Aug., 1925.)

Aneurysm of the femoral or iliac arteries presents a pulsating mass in the region of the groin—above or below as the case may be, because both arteries are usually involved. The circulatory changes in the extremity are such as might be expected—cold, pale, cyanotic, moist foot and obliteration or irregularity of the dorsalis pedis artery.

Popliteal aneurysm is the commonest of peripheral aneurysms, comprising about 50 per cent of all. It is usually fusiform, but may be saccular. Before it can be made out on physical examination it may cause coldness or numbness of the foot, or an intermittent limp. Once the expansile pulsation appears in the popliteal space, the diagnosis is clear. Injury to the peroneal nerve may cause foot drop.

Purpura fulminans is a condition of ecchymosis going over to a solid area of a hemorrhagic, almost gangrenous, state. The skin is bluish red, or reddish black. It involves any extremity, or the trunk, and the involvement is often symmetrical. It occurs as a complication of scarlet fever, typhus, variola hemorrhagica, measles, and septicemia. The primary change, according to Adams, is in the endothelium of the vessels. It is very rare. (See McConnell and Weaver: Purpura Fulminans, J. A. M. A. 78: 165, Jan. 21, 1922.)

Glomus.—Glomangioma, a small cutaneous, or subcutaneous tumor, which is an arteriovenous anastomosis in the stratum reticulare of the cutis. It was formerly called "painful tubercle." A frequent site is beneath a nail. They appear as small bluish nodules on the extremities and occasionally on the shoulder girdle. They are full of nerve trunks and produce severe neuralgic pains of the radiating type. Local surgical excision produces complete relief. X-ray treatment is of no avail. In a series of cases 44 were on the upper extremity (20 subungual) and 18 on the lower (1 subungual). (See Bailey: The Cutaneous Glomus, Am. J. Path. 11: 915, Nov., 1935.)

PERIPHERAL VASCULAR DISEASE

	AGE	SEX	CAUSE	MODE OF ONSET	LATERALITY	LIMB AFFECTED	SYMPTOMS
Organic endarteritis obliterans	Old	50 50	Arteriosclerosis; diabetes	Insidious; exercise makes worse	Unilateral	Lower	Intermittent claudication, ulcers and gangrene, obliteration dorsalis pedis
Thromboangiitis obliterans	Young	M 80%	Tobacco (!), inflammation of arteries and veins	Exercise; dependency of limb	Unilateral or bilateral	Lower	Nothing, fever, claudication, ulceration and gangrene, obliteration dorsalis pedis
Embolism	Adult	50 50	Heart	Sudden	Unilateral	Lower	Pain, coldness of limb, gangrene
Functional Raynaud's disease	20-30	F 90%	Neurotic personality (!)	Exposure to cold; emotion	Bilateral, symmetrical	Upper	Cold to touch, color changes: white-red-blue. Later, ulceration and gangrene
Erythromelalgia	25 50	50 50	Nerve wound or unknown	Exposure to heat, dependency	Bilateral usually	Lower	Red blue; painful, relieved by cold and elevation
Acrocyanosis	Any age	F +	Neurotic personality	Insidious, permanent when begun	Bilateral	Lower	Red-blue mottling; later, ulceration
Livedo reticularis	25 50	50 50	?	Exposure to cold, 60% of cases	Bilateral	Lower 85%	Mottled, blotchy, reticular bluish discoloration; ulceration rare

Arteriovenous Aneurysm.—Fistulous connection between an artery and a vein. They may occur between the external carotid and external jugular, the internal carotid and cavernous sinus (carotid incidence 20 per cent), in the scalp or lip, the subclavian (9 per cent), the femoral (25 per cent of all), the popliteal, and tibial. In a series of 33 cases 27 were due to trauma (bullet wound, knife wound), and six were congenital.

Local Signs.—On inspection—tumor, usually pulsatile; on palpation the feeling that vessels are involved is unmistakable (there is often a feeling as of handling a basketful of worms or eels, usually a thrill); on auscultation there is almost always a loud systolic bruit.

Remote Signs.—In arteriovenous aneurysm of internal carotid and cavernous sinus, unilateral pulsating exophthalmos is almost invariable. In the subclavian type there are swelling, redness, heat, and pain (or rather tenseness) in the arm: the dilated vessels of collateral circulation or venous obstruction are prominent. The same signs and symptoms apply to the leg in the femoral type. Hemihypertrophy of a limb is common: it may extend to the bones and cause lengthening of the limb. (See Reid: *Arch. Surg.* 10: 602, March, 1925; *ibid.*: 10: 813, May, 1925; *ibid.*: 11: 1, July, 1925; see also Horton: Hemihypertrophy in Congenital Arteriovenous Fistula, *J. A. M. A.* 98: 373, Jan. 30, 1932.)

Hand types—Acromegaly.—"The hands are very large, but of regular form: their thickness and width are relatively greater than their length and attention is at once attracted to them on seeing the patient. The joints of the fingers are not specially enlarged in proportion to the bones, which have certainly shared in the hypertrophy; the fingers present a somewhat flattened appearance. The width of the nails is increased." (Marie, 1886.)

Myxedema.—"The hands peculiarly broad and spade-like, as if the whole texture were infiltrated." (Gull, 1873.)

The Feet.—The internist is often called up to render judgment on disorders of the foot, either primary or as a complication. We have considered the cold, hot, blue, white, red, mottled, ulcerated and gangrenous feet or toes of peripheral vascular disease above.

Nutritional disorders may have manifestations in the feet. Many cases of painful feet are due to overeating—obesity. Gout, frank or mild, must always be remembered. The diabetic patient requires constant re-examination of the feet.

"Feet are among the first structures to show evidence of age, wear and tear, stress and strain." "Bad feet are good barometers of failing health." (Lewin: *The Foot and Ankle*, Lea and Febiger, 1941.)

Imbalance of the foot, from flatfoot, badly fitting shoes, etc., may quite as often show up as pain in the calf, knee, hip, or pelvis.

There are a number of bursae about the foot—under the heel, under the arch, between the toes, which commonly become inflamed and cause pain and disability. The condition is often treated as flatfoot. (Hertzer: *Bursitides of the Plantar Surface of the Foot*, *Am. J. Surg.* 1: No. 3, 1926.)

Painful heel may be due to calcaneal spurs (gonococcic?) or bursitis (very common).

Köhler's disease (isolated disease of the scaphoid) may cause pain, limping, and disability. It is not tuberculous or syphilitic.

Chapter 12

FEMALE GENITALIA

The external female genitalia are subject to the same diseases as those of the male, i.e., venereal infections, tumors, etc.

Chancre may appear anywhere, but it notoriously eludes discovery. The typical Hunterian chancre is very exceptionally encountered. It is most often found on one lip of the vulvae. Chancre of the cervix is rare. Absence of the satellite bubo is "strong presumptive evidence of the primary chancre being located on the cervix uteri." (Stookey and Roberts: *Am. J. Syph.* 12: 212, 1928.) Edema of the cervix may mask chancre, and generalized edema of the external genitalia may be the only sign of the site of entrance. Condylomata may obscure the chancre. Condylomata lata are typical secondary lesions of the external female genitalia.

Chancroid and **lymphogranuloma venereum** have very similar appearances, but the Frei test should differentiate them.

Abscess of Bartholin's glands is one of the manifestations of gonorrhea in the female.

The tumors of the vulva include fibroma and carcinoma.

Kraurosis vulvae and **leucoplakia** produce itching, as do a host of other conditions, such as trichomonas infection, mycotic and ringworm infections, but all of these are of little interest to the general internist.

Vaginal examination is, strictly speaking, part of the routine diagnostic examination, but unless there is some fairly definite indication, it can usually be omitted. The indications are to find a cause of anemia, weight loss, nervous symptoms, abdominal tumors, endocrine dyscrasia, fever, arthritis (gonococci, menopausal), vomiting (pregnancy). The value of the internists' vaginal examinations is to decide whether the patient had best be sent to the gynecologist for a detailed examination.

Failure to make a correct diagnosis more often comes from failure to pursue a routine than from any other cause. The patient should remove corset and loosen any clothing tight about the abdomen. The bladder should be emptied. The pelvis should be tilted so that the intestines, omentum, etc., are moved out of the pelvis.

The examination consists of (1) *inspection* of the external genitalia, (2) *bimanual* examination, (3) examination by *speculum*.

Bimanual examination is carried out by using the left forefinger (and middle finger) in the vagina and the right fingers on the abdominal wall to manipulate the fundus uteri, etc. Using the left hand as the vaginal palpating finger is routine with gynecologists: the reasons given are that left-sided pelvic lesions are more common than right, and that the right hand is free to handle instruments. However, the hands may be interchanged if conditions are found to be such that a complete understanding of conditions is not accom-

plished by using the left hand intravaginally. The forefinger is used alone at first, but in most married women the middle finger can also be introduced without discomfort. The examining fingers should hug the posterior vaginal wall rather than the anterior because pressure against the urethra may cause discomfort.

Palpate first the cervix uteri: note size, shape, consistency, size of external os, the direction in which the cervix points, presence of lacerations, polyps, any rough or indurated areas, and whether digital manipulation causes bleeding.

Next engage the cervix and fundus of the uterus between the palpating hands. If the fundus cannot be felt in front, see if it is in the posterior cul-de-sac. Note size, movability, tenderness, irregularity.

Then proceed to palpation of the left ovary and tube.

Then the right.

The normal ovaries can usually be palpated.

The normal tube cannot be felt, but any abnormality, such as pyosalpinx, should be felt. Note again, fixity or movability, tenderness, size, and consistency.

Speculum examination extends and confirms the first part of the bimanual examination and allows the examiner to see the exact condition of the cervix—whether any growth, laceration, or discharge is present.

A mere listing of the pelvic diseases which are of interest to the internist is sufficient to suggest the physical signs which they produce on examination per vaginum:

Pregnancy, ectopic pregnancy, inflammation of the adnexa, displacement of the uterus, fibromyoma, carcinoma of the fundus or cervix of the uterus, ovarian cyst and other forms of ovarian tumor (with the possible complication of twisted pedicle).

Lacerations, inflammation and polyps of the cervix, cystocele, rectocele.

The only one over which we should pause is ectopic pregnancy and this, because it so often presents as an acute abdomen. The ways in which an ectopic pregnancy may produce symptoms are very numerous, but they can all be explained by the variety of courses the disease may take. The history is more important than the physical examination. The following symptoms and signs should always arouse a diagnostician's suspicions of ectopic pregnancy:

1. History of a missed, delayed, prolonged, or anomalous menstruation. This is explained by the fact that a true pregnancy begins with the formation of a decidual membrane in the uterus. Then the uterine membrane begins to become detached and there is:

2. History of a characteristic bloody vaginal discharge (reddish brown) mixed with mucus that does not clot.

3. Sudden, sharp, colicky abdominal pain referred to the region of the vagina or epigastrium.

4. Faintness may or may not accompany the abdominal pain.

5. Extreme sensitiveness in moving the cervix.

6. An enlarged, empty uterus, slightly displaced forward, upward, or to one side.

7. A sensitive, fluctuant, growing mass in the cul-de-sac, with increased pulsation of the uterine artery in that side. This may take place before rupture of the tube. The reason there is so much sensitiveness is that the tube is stretched. This also causes the frequent complaint of lower abdominal soreness.

8. Slight elevation of temperature, 99° to 100.5° F., without any other evidences of pelvic inflammation.

9. Repeated attacks of abdominal pain when under observation, at rest, without explainable cause, with coincident increase in the size of the tumor.

10. Bluish discoloration of the umbilicus.

Chapter 13

MALE GENITALIA

Urethra.—Acute uncomplicated gonorrhea carries no implications for the general internist. In the presence of one of its possible complications, however, he may have to strip the urethra or use other means for the identification of the gonococcus.

The immediate and focal complications which usually call to the urologist are epididymitis, prostatitis, prostatic abscess, cystitis, and pyelonephritis.

The systemic complications are: (1) septicemia and pyemia (gonococci may be cultured from the blood. Twenty-five per cent of all puerperal sepsis is gonococcal), (2) endocarditis and pericarditis, (3) arthritis (q.v.), (4) periostitis, (5) meningitis, (6) iritis, (7) parotitis.

Penis and Prepuce.—Ulcer, chancre, chaneroid, benign ulceration, malignant ulceration.

Chancre.—*Incubation period* is twelve to forty days after inoculation (suspicious intercourse).

Physical Characters.—It tends to be single rather than multiple. It is painless. It begins as a macule, then becomes a papule, after the fourth day induration begins, then erosion and ulceration begin, and adjacent lymphatic enlargement appears on the seventh to the fourteenth day. The border of the ulcer is well defined; there is little inflammatory reaction around it; the base is clean; it is of raw muscle color, and the discharge is serous rather than purulent.

The classical lymphadenopathy is the "satellite" bubo, or single unilateral enlarged node, which does not break down. This abstraction of the older syphilographers* is no longer emphasized, because in about 70 per cent of instances the lymphadenopathy is multiple; but even if multiple there is usually one large prominent bubo, and the old rule that lymph nodes of syphilis do not break down is absolutely sound.

Diagnosis of the perfectly typical chancre requires only elementary skill. Atypical chancres are, however, legion. And as Dr. John H. Stokes well says, the diagnosis of the chancre is today not a clinical but a laboratory problem with the dark-field identification of the treponema. The attitude of waiting for the evolution of the stages of induration, ulceration and lymphadenopathy belong to an earlier period, and wastes valuable time.

Chaneroid.—Soft chancre is a specific ulceration caused by the streptobacillus of Ducrey. The incubation period is about three days. It is as likely to be multiple as single. Induration is rare, unless a superimposed chancre is present. Lymphadenopathy is usually multiple or rarely single, and in either case the enlarged nodes suppurate. Chaneroids are painful, bleed easily.

*Ricord: "It is the faithful companion of the chancre: it follows the chancre as the shadow does the body."

Lack of even elementary personal cleanliness is a factor in the development of chaneroid. Significant in this respect is the Army record that from 1929 to 1937 no case of chaneroid appeared among officers.

The whole duty of the diagnostician in the presence of what he may suspect to be a chaneroid is to make repeated dark-field examinations to eliminate chanere. The therapeutic test of prompt resolution with the use of cleanliness and application of a mild antiseptic solution, such as potassium permanganate, is convincing.

Benign ulcer occurs on prepuce and glans as the result of uncleanness.

Malignant Ulcer.—A good proportion of malignancies of the glans penis begin as ulcerations. The associated lymphadenopathy may suggest syphilis, but the age of the patient, the history of the long existence of the ulcer (in practice the patients usually do not seek advice for a year or more) without the appearance of secondaries, and the negative dark-field rule it out. Biopsy is demanded on all penile ulcerations in patients over fifty when the dark-field is negative.

Tumors.—Carcinoma of the penis represents about 1 per cent of all male carcinomata. Besides the ulcerative type, the fungous papillomatous type is next most common.

Lymphogranuloma venereum is a specific infection of the genital organs. Young adults are the most frequent victims; males oftener than females. It is caused by a filtrable virus. It begins as a primary lesion, usually evanescent and overlooked, followed by a subacute, indolent, inguinal lymphadenitis which breaks down and produces fistulas, later considerable scarring. The course is chronic, lasting several years. In women, due to their different lymphatic drainage, it tends to localize in the deeper lymphatic structures and produce esthiomene and genitoanorectal syndromes. Rectal stricture is a complication. The Frei test (intracutaneous injection of an antigen prepared from active buboes) is specific.

Examination of Testis, Epididymis, and Scrotum.—The patient should be standing in front of the seated examiner, with trousers off, or completely let down, and shirt rolled up to the nipple line. Examine the skin of the scrotum for eczema, ulceration, or especially fixation to underlying structure: if it is fixed anteriorly this suggests gumma, if posteriorly, tuberculosis, while a new growth may invade any part of the overlying skin.

Palpate the parts of the testis in a definite order: *first* the body of the testis, comparing the two sides as to size, consistency and irregularity of consistency; *second*, remember the tunica vaginalis, that it is usually on the anterior surface of the testis, and intimately blended with it, but in a few cases on the posterior surface; *third*, palpate the epididymis, globus major, and globus minor (a rough lumpy epididymis is almost pathognomonic of tuberculosis); *fourth*, palpate the vas deferens in the manner described by Lockwood—"Pass the index finger under the neck of the scrotum, pinch the thumb down upon it, and slip the constituents of the scrotum through your fingers from within outwards. You ought to feel the vas which is like a hard whipcord. You will feel a number of other small cords and strings and fibers which you cannot define. You may pos-

sibly be able to feel the nerves of the cord, more especially the genito-erural and branches of the ilio-inguinal, but I think the fibers which you feel are probably the fibers of the cremasteric muscle. Unless you feel these things clearly and accurately you are not feeling a normal spermatic cord."

Translucency.—The commonest enlargement of the testis is hydrocele of the tunica vaginalis. The translucency test indicates whether a tumor is liquid or solid. The neck of the scrotum is grasped between finger and thumb and the swelling rendered tense. A pocket flashlight is pressed against the distal side of the swelling. For perfect elucidation the room should be darkened, or the examiner use a rolled up cylinder of cardboard, pressing one end against the tensed scrotum opposite the source of illumination, and looking through the other. A pinkish light will be seen glowing through the tumor if it is fluid. The test is very important because it differentiates hydrocele from hernia as well as solid tumor of the testis.

Examination of the Lymphatics.—There are three sets of lymphatics in the cord: (a) those following the cremasteric artery, which pass to the inguinal nodes; (b) those following the artery to the vas which pass to the internal iliac nodes, and (c) those following the spermatic artery which pass to the para-aortic nodes just below the origin of the renal arteries. Neoplasm of the testis may, therefore, be expected to show secondary deposits in the para-aortic nodes above the umbilicus. These may be palpated in the knee-chest position.

Testicular sensation consists of a peculiar sickening pain when the testis is squeezed. Absence of sensation is good confirmatory evidence of gumma of the testis.

Hydrocele.—All ages are subject to hydrocele. In most cases the cause, idiopathic hydrocele, cannot be ascertained. Cartier stated that 25 per cent of supposedly idiopathic hydroceles are tuberculous (Bull. Acad. de méd., Paris 105: 1034, 1931). Congenital hydroceles, appearing soon after birth, are strongly indicative of tuberculous, transmitted from the mother: the infants usually die early of a general miliary tuberculosis. Congenital syphilis may be in the background of a hydrocele in infancy. Hydrocele may mask gumma and neoplasm of the testis or tuberculous epididymitis.

Filariasis, or elephantiasis of the scrotum, would be a distinct curiosity in temperate climates. Milroy's disease is usually accompanied by a lymph-edema of the scrotum.

DISEASES OF THE SPERMATIC CORD.—Varicocele of the veins of the pampiniform plexus is usually idiopathic, but may be indicative of mechanical obstruction of the spermatic vein in the pelvis by tumor, hernial truss, etc. The general internist will find most of his interest in the subject concerned with the emotional reaction and morbid fears its presence excites in some youths.

Gumma occurs, though rarely, in the spermatic cord: Thompson collected only 13 cases in the literature.

Hydrocele and cysts of the cord have no significance in general pathology.

Tumors of the cord include lipoma, fibroma, myxoma, leiomyoma, sarcoma, and teratoma. Sarcomata are fairly frequent.

DISEASES OF THE EPIDIDYMISS—

Gonorrheal epididymitis occurs in about 10 per cent of cases of acute gonorrhea.

Tuberculosis of the epididymis is the common tumor of that structure. It is seldom seen confined to the epididymis, but combined with tuberculosis of the seminal vesicles and prostate, it is frequently encountered. The epididymis in this process, however, is usually the focal point, the first to show the manifestations and the most vocative. Any swelling of the epididymis should suggest tuberculosis, and this may come on acutely or gradually, usually without pain or discomfort. Loss of sexual power usually brings the patient for examination. A urethral discharge may also be the sign which draws the attention. The general signs, loss of weight, fever, and malaise, are by that time manifest. Pulmonary tuberculosis can be detected in about 85 per cent of cases. As Keyes put it, the disease "is always flitting between bone and lung and urinary tract."

Syphilis of the epididymis is rare, but does occur. Gumma is easily outlined, and not adherent, and occasionally somewhat nodular. Hydrocele of the cord may mask it.

DISEASES OF THE TESTIS.—Orchitis, as a complication of mumps, is a nonsuppurative inflammation with a tendency to atrophy of the organ. It is far more serious than it is usually regarded. First, it is an indication of a generalized distribution of the infection and an associated encephalitis may produce coma or delirium. The after-results are often tragic. There is extant a letter from George Washington to Dr. Benjamin Rush, praising him for his activity in quarantining patients with mumps during an epidemic in Philadelphia and stating that he, President Washington, had good reason to know how serious the disease can be. It may be conjectured that is the reason he is the Father of his Country rather than the father of a family of his own. I know half a dozen men who have been feminized for life by this complication: one of them has pendulous female breasts which hang below his umbilicus and can be swung over his shoulder. Typhoid fever, smallpox, and gout may also be complicated by orchitis. Involvement in other infections is very rare.

Syphilis, unlike tuberculosis which usually attacks the epididymis, usually involves the testis itself. Syphilitic orchitis is found in both congenital and acquired forms. The organs may be enlarged, globular, indurated and smooth. Sometimes the induration exists without much enlargement—"billiard ball testis."

Gumma may be single or multiple in the testis, which is enlarged, rounded, nodular, or smooth as the case may be. It is usually insensitive to pressure. Hydrocele frequently accompanies it. The epididymis is early involved. Adhesions to the scrotum are common. Sometimes the gumma breaks down, forms a sinus through the scrotum, and discharges cheesy matter. A fungating granulomatous mass eventually protrudes through the resultant ulcer. Usually only one testis is involved.

Tumors of the Testis.—Hertzler (*Surgical Pathology of the Genitourinary Organs*, Lippincott, 1931) argues for a simple classification of the malignant

tumors, calling the most frequently encountered *seminoma*, made up of cells like those of the seminiferous tubules; and, second in frequency, the *teratoma*, including dermoid. Among the teratoma should be placed the rare chorion-epithelioma which produces gynecomastia.

The diagnosis of malignant tumor of the testis is largely a matter of excluding tuberculosis and syphilis. There are no pathognomonic physical signs. Pain is seldom a complaint. The onset is insidious. The normal shape of the testis is usually preserved. The size is not important in differentiating gumma. The consistency is of uniform hardness in nearly all cases, although areas of necrosis may occur.

The Prostate.—In the digital examination of the prostate per rectum, the finger should first locate the median furrow and identify the two lobes of the gland. Normally it feels firm and elastic. Following down the median furrow the soft membranous urethra is felt. On either side are Cowper's glands. Following up the median furrow, a little to the side of the top of the prostate, are the seminal vesicles. They cannot be palpated unless distended.

The internist is interested in prostatic hypertrophy because of the impetus it gives to the progress of chronic nephritis. Uremia is seldom seen except in the prostatic patient. Even if no symptoms are produced by the enlarged prostate, it may affect kidney function, and a routine examination, under these circumstances, is advisable.

Another value of the examination is for the purpose of stripping the vesicles to uncover latent gonococcic infection.

Chapter 14

THE RECTUM

There are three procedures in the examination of the rectum: (1) inspection of the perineum and anus, (2) digital examination, and (3) instrumental examination (See Chapter 31, p. 835).

1. Inspection.—After adequate exposure of the patient, which is best secured by having the patient assume the knee chest position, or lying on one side with the upper thigh flexed, then with plenty of light, a careful scrutiny should be made of the territory at some distance from the anal opening, such as the perineum, the buttocks, and the external genitalia. Scars, draining sinuses, pilonidal sinuses, anal pruritus (with its thick, moist macerated skin), venereal lesions, such as chancre, chaneroid, and lymphogranuloma, and condylomata acuminata are looked for. Observation should be made as to the condition of the walls of the anal canal, or *anal patency*. When the margins of the canal, which are normally in apposition, stand open, one must think of diseases of the central nervous system, in the absence of local pathology.

Hemorrhoids constitute the most commonly found anal lesion. These may be of the type "that come down when straining at stool" and are reducible by pressure, which merely empties the overdistended veins, or the bluish firm thrombosed type. Anal skin tags are the remnants of previously thrombosed external hemorrhoids. *Anal epithelioma* may simulate an anal tag, but fortunately is rather rare. (Baile: *Practical Proctology*, Saunders, 1937.) It differs from an anal tag in that it is nodular or has a pebbled surface.

An *anal fissure* involves the skin of the anal wall, and if acute there is much accompanying anal spasm which makes it difficult to expose. The majority of fissures are near the posterior midline, a few anterior, principally in females, but the rare lateral fissure or ulcer should make one suspicious of tuberculosis or syphilis. While an *abscess* may be observed pointing at some distance from the anal margin, they still have their origin there. They are most frequently observed in the buttocks, the perineum, the vulva, or scrotum. If in the sacrococcygeal region, an infected pilonidal cyst should be thought of.

The term *prolapse* can refer to any tissue protruding from the anal outlet, such as internal hemorrhoid, *hypertrophied anal papillae*, *rectal polyp*, the papillae being covered with skin, and the polyp with mucosa, or a *complete prolapse* of the rectum involving all layers of the rectal wall.

Among the skin lesions one of the most commonly found is *pruritus*, which, depending on its severity, manifests itself by a thick, moist, macerated skin, usually with some indication of secondary infection from scratching. Of the ulcerative lesions, the primary lesion of *syphilis* is noted as a painless smooth-based, well-defined ulcer. Wartlike perianal growths could be secondary syphilis, *condylomata lata*. The dirty looking painful ulcer may be a *chaneroid*. While the primary lesion of *venereal lymphogranuloma* is rare, the Frei test

should be conducted on any rectal or perirectal lesion not falling into other classifications. *Condylomata acuminata* are moist cauliflower-like perianal excrescences.

2. Palpation.—Before endoscopic examination is made, a thorough digital exploration should be made of the anal canal and rectum with a well-lubricated, gloved, index finger inserted slowly. By this method we may palpate the *fistulous tract* as a subcutaneous "cord" leading to the anal canal. The location of the original source of the perirectal abscess in the dentate margin can often be found by bidigital examination. *Internal hemorrhoids* cannot be readily determined by palpation, unless they are thrombosed. One can usually feel the firm edges and underlying scar tissue of an old *anal fissure*.

In the early period a deep peri-rectal abscess can be felt as a doughy swelling bulging out into the lumen of the rectum proximal to the dentate margin. Inflammatory *stricture* of the rectum should be readily palpated. *Polyps* are not easily felt, and *adenocarcinoma* may early present as a soft polyplike mass, or as an ulcer, but the long-standing ulcerating carcinoma will demonstrate much infiltration of the surrounding tissues. The *annular carcinoma* feels somewhat like a lacerated cervix. *Fecal impactions* or foreign bodies are frequently overlooked when we fail to make a rectal examination.

Extrarectal lesions, such as a *pelvic mass*, *carcinoma of the prostate*, and the condition of the pyriformis and coccygeus muscles as described by Thiele (Tr. Am. Proctol. Soc. 37: 145-155, 1936) are identified by rectal palpation. Likewise, the obstetrician and the gynecologists make free use of digital examination.

Chapter 15

THE NERVOUS SYSTEM

DIAGNOSIS OF DISEASES OF THE NERVOUS SYSTEM

Introductory

The general practitioner of internal medicine should know enough about the diseases of the nervous system to make and record the findings of a routine neurologic examination. After it is completed, he should be able to say whether there is any disease present; whether it is functional or organic; if the latter, what structures are involved—peripheral nerves, meninges, spinal cord, basal ganglia, cerebellum or cerebrum; if functional, whether it is a neurosis or a psychosis; and in most instances hazard an opinion as to etiology—degenerative, infectious (*syphilis, tuberculosis, meningococcus*, brain abscess, encephalitis, influenza or anterior poliomyelitis); toxic (*alcohol, lead, arsenic, etc.*), or neoplastic.

After these problems have been solved, either definitely or tentatively, the general internist may wish to refer the patient to a neurologist, but the separation between general medicine and neurology has been carried too far. The nervous system is certainly a part of the body, and the general internist should be prepared to stand and deliver an opinion on its condition in every individual case.

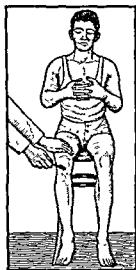
Outline of Examination of the Nervous System

In examination of the nervous system note:

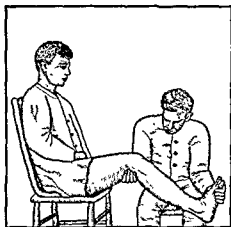
I. Motility

A. REFLEXES.—

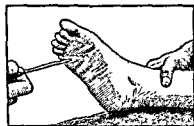
1. *Pupillary*.—See p. 264.
2. *Jaw Jerk*.—The patient opens his mouth, the chin is grasped with the left thumb and forefinger; a brisk tap on the examiner's own thumb results in contraction of both masseter muscles. Reflex center—pons, mesencephalic root of the fifth cranial nerve. (See Harrison and Corbin: Central Pathway for the Jaw Jerk, *Am. J. Physiol.* 135: 439, 1942.)
3. *Supinator Jerk*.—Arm bent, hand resting or hanging; a tap on the distal end of the radius results in a flexion of elbow joint. Center—sixth cervical segment.
4. *Biceps Jerk*.—Arm in same position as above, grasp the patient's elbow with thumb on the biceps tendon; tap on the examiner's thumb results in contraction of the biceps. Center—fifth and sixth cervical.
5. *Triceps Jerk*.—Lift patient's arm, grasping it loosely around the forearm—slight flexion at elbow—a tap on the triceps tendon just above the olecranon results in extension of the arm. Center—eighth cervical.



Patellar Reflex.
Re-enforcement



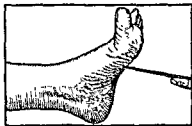
Ankle Clonus



Babinski Plantar
Reflex.
Normal Reaction.



Babinski
Plantar
Reflex.



Babinski Plantar
Reflex
Positive Reaction.

Proper line of
contact for
stimulation.

6. *Hand Reflexes*.—The *radioperiosteal* reflex is obtained by holding the patient's hand in mid-pronation on its ulnar surface while the forearm is relaxed. The styloid process of the radius is percussed, and the resultant movement is slight flexion of the forearm. Lying down, the same area is tapped when the arm is loosely thrown over the abdomen in semiflexion.

Hand clonus is obtained in cases of spasticity by suddenly extending the wrist dorsally.

The *Leri* and *Mayer* reflexes are present normally and their absence is suggestive of a lateral tract lesion involving those fibers which go to the cervical cord. The Mayer reflex is obtained by flexing the metacarpophalangeal joint of the middle finger sharply to the point of pain. The thumb reflexly goes into adduction and extension. The Leri reflex is elicited by rolling the fingers into the palm of the hand and continuing the movement so that the wrist is flexed, with the result that there is a reflex flexion of the forearm.

The *Hoffman* reflex is a flexion of the terminal phalanx of the thumb when the terminal phalanx of the middle finger is snapped between the thumb and index finger of the examiner. Its presence suggests a lesion of the lateral motor tracts.

There are, however, no adequate signs of upper motor neurone lesions for the upper extremities as the Babinski toe sign is for the legs.

7. *Knee Jerk*.—"With the hip and knee joint in a slightly flexed position while all the leg muscles are relaxed, tap lightly with the finger or percussion hammer the region of the ligamentum patellae. Every tap is immediately followed by a lightning-like, very noticeable contraction of the quadriceps muscle which you can both feel and see." (Erb: *Arch. f. Psychiat.*, 1875.) Increased in spastic paralysis. Absent in ataxia, flaccid and peripheral paralysis. *Re-enforcement*.—Sometimes the knee jerk and other reflexes are poorly elicited because the patient cannot relax. Attention may be diverted by having the patient hook the fingers of the hands together and pull constantly, or in jerks at command, at the time the tendon is tapped.
8. *Ankle Jerk*.—With the patient kneeling, tap the Achilles tendon and watch for reflex extension of the foot. "The epiconus medullaris of the cauda equina may be involved alone, leading to degenerative atrophy of the muscles innervated by the sacral plexus, particularly the peronei and the glutei. If the lesion be limited to the gray matter of the epiconus, the achilles reflex is abolished, but the knee jerk can be elicited, and the sphincters remain unaffected." (Barker.)
9. *Ankle Clonus*.—If in spastic paralysis "you make a sudden strong flexion of the (ankle) joint and at the same time hold the leg firmly in the flexed position, the foot is thrown into rhythmic alternating

flexion and extension which follow each other in rapid succession and stop spontaneously after a shorter or longer interval." (Westphal: *Arch. f. Psychiat.*, 1875.)

10. *Cutaneous Reflexes.*—

Abdominal.—Stroking parallel with the costal margins the transversalis and rectus contract on the side of the stimulus, pulling the linea alba and umbilicus in that direction. "In young and healthy persons the abdominal reflexes are constantly demonstrable. In the early stages of multiple sclerosis these reflexes disappear." (Müller: *Neurol. Centralbl.*, 1905.)

Cremasteric.—Stroke the skin along the inner border of the thigh. The homolateral cremasteric muscle contracts, raising the testis.



Fig. 54.—Positive Babinski sign.

Babinski.—Normally, "tickling on the sole of the foot results in flexion of the thigh on the pelvis, the leg on the thigh, the foot on the leg, and the great toe on the metatarsus." In spastic paralysis "a similar stimulus also gives rise to flexion of the thigh on the pelvis, of the leg on the thigh, the foot on the leg, but the great toe, instead of being flexed, is extended on the metatarsus." (*Compt. rend. hebdomadaire de l'Académie des Sciences et de l'Institut de France*, 1896.)

(Other reflexes—patellar clonus, Oppenheim, Gordon, etc.—are amusing but have no significance other than that which is attached to the ankle clonus and Babinski.)

B. PARALYSIS.—

1. *Flaccid Paralysis*.—Lower motor neurone and peripheral nerve type. Loss of reflexes, limp, usually atrophied muscles, spasm due to action of unopposed muscles. Peripheral nerve palsy, cauda equina injury, anterior poliomyelitis, multiple neuritis, spinal cord section, hysteria.
- a. *Tests for Paralysis of Individual Nerves*.—

- (1) *Oculomotor* (third cranial).—*Ptosis* and paralysis of external ocular nerves except superior oblique and external rectus. Cannot lift eyelid, nor rotate eyeball toward nose, or upward or downward. There is *external strabismus* from unopposed action of the external rectus. The pupil is dilated from paralysis of the sphincter iridis, and does not react to light or accommodation. Complete paralysis of all branches of the third nerve is rare, ptosis alone being usual.

The levator palpebrarum is also innervated, partially by the cervical sympathetic. Paralysis results in Horner's syndrome—ptosis, constriction of the pupil, and enophthalmos, with associated heat, redness, and edema of the face on the same side.

- (2) *Trochlear* (fourth cranial) superior oblique paralysis—*diplopia* when the eyes are turned any direction but upward.
- (3) *Motor branch* of the trigeminus (fifth nerve) innervates muscles of mastication—masseter, temporal, and pterygoid. *Inability to move the jaw sideways*.
- (4) *Facial* (seventh cranial) nerve innervates the facial muscles—orbicularis palpebrarum, frontalis, orbicularis oris, buccinator, risorius, etc. Paralysis results in *inability to wink, screw up the eye tight*, whistle, and there is lacrimation, one-sided drooping of the face, and tenting of the cheeks on respiration. If chorda tympani is involved, there are taste disturbances and tinnitus.
- (5) *Vagus* (tenth cranial) and glossopharyngeal (ninth cranial) paralysis result in bulbar palsy (pharynx, tongue, and muscles of deglutition). On attempted swallowing, food comes out through the nose. Swallowing is difficult with bilateral (diphtheritic and central lesions), not with unilateral. Unilateral involvement—*tongue on protrusion* deviates to one side. On examining pharynx with tongue depressor and asking patient to say "Ah!" the raphe and uvula deviate to sound side (normally the raphe pulls up). Nasal voice resonance and sometimes aphonia. Laryngeal paralysis is made out with laryngoscope.
- (6) *Spinal accessory* (eleventh cranial) nerve supplies the sternomastoid and part of the trapezius. Paralysis results in *down-*

ward and outward displacement of the scapula. The sternomastoid no longer stands out on rotation of the head to the opposite shoulder. (On account of double innervation of the sternomastoid from second cervical, it is not usually completely paralyzed.) Torticollis is not usually due to disease of nerve.

- (7) *Hypoglossal* (twelfth cranial) nerve innervates the tongue. Paralyzed half of tongue becomes wrinkled and atrophied. When the tongue is protruded, the healthy side causes the tip to be pushed around to the paralyzed side in a sickle-shaped curve.

- (8) *The Shoulder*.—The deltoid muscle is supplied by the circumflex nerve. The rounded contour of the shoulder is lost and the arm cannot be raised laterally, forward or backward.

Serratus magnus palsy from lesion of the long thoracic nerve results in inability to raise the arm above the horizontal plane. When the arm is raised, the shoulder blade flares out—winged scapulae.

Infra- and supraspinatus palsy is due to lesion of the suprascapular nerve. There is loss of external rotation of the arm, and atrophy of the muscles over the scapula.

- (9) *Musculocutaneous nerve* innervates the biceps. Paralysis very rare.
- (10) *Musculospiral nerve* supplies triceps, brachialis anticus, brachioradialis and extensor carpi radialis. Paralysis causes wrist drop. The grasp, on shaking hands, is weak in mild cases. When the triceps is involved, the arm cannot be extended at the elbow.
- (11) *Ulnar nerve*, innervates the flexors of the proximal phalanx, the lumbricales and extensors of the distal phalanges. Paralysis causes claw hand. The thumb test (signe de journal of Froment-Presses medicale, Oct. 21, 1915) is performed by asking the patient to grasp a sheet of paper in both hands by the thumb and forefinger and pull it apart. On the sound side the whole length of the thumb is in contact with the paper, compressing it against the index finger, the terminal phalanx of the thumb being extended. On the paralyzed side only the thumb-tip presses the paper, with the terminal phalanx markedly flexed by the action of the flexor pollicis longus, innervated by the anterior interosseus nerve, a branch of the median.

In ulnar paralysis there is anesthesia of the little finger and half the ring finger and the corresponding part of the hand.

- (12) *Median nerve* supplies the pronator radii teres, flexor, carpi radialis, palmaris longus, flexor sublimis digitorum, flexor longus pollicis, flexor profundus digitorum, pronator quadratus. Paralysis results in weakness of flexion of the wrist, deviation of the hand to the ulnar side when flexion at the wrist is carried out against resistance, inward rotation of the arm when pronation of the forearm is attempted, no movement of thumb and forefinger when clenching the fist is attempted (only the three outer fingers clench).
- (13) *Anterior crural nerve* or *femoral nerve* supplies the great muscles of the upper leg. Neither flexion at the hip nor extension at the knee can be carried out. Walking is difficult. The leg is used as a stilt. The patient pushes back the knee to make it stiff.
- (14) *Anterior tibial* or *deep peroneal nerve*, a branch of the sciatic supplies the tibialis anterior, extensor pollicis longus, extensor digitorum longus, and peroneus tertius. Paralysis causes *foot drop*. The toes are flexed. Results in steppage gait. There is anesthesia over the outer surface of leg and dorsum of foot. If the sciatic is injured or severed, there is not only foot drop but wasting of the leg, especially the gastrocnemius.
2. *Cauda equina injuries* result in paralysis of all the muscles of the lower limb with anesthesia below the folds of the groin in front, including the genitals, below the upper part of the buttocks, with loss of bladder and rectal control. If the first, second, and third lumbar roots escape, the anesthesia is less extensive, and the paralysis spares the quadriceps, leaving the knee jerk intact, with loss of ankle jerk. A lower lesion, involving mostly the sacral roots, results in no paralysis of the lower limbs, but the characteristic "saddle" anesthesia, an area on the buttocks, perineum, scrotum, penis, and a small strip down the internal aspects of the thigh. There is bladder and rectal sphincter paralysis.
3. *Generalized flaccid paralysis*, or flaccid paralysis involving large and unrelated groups of muscles, occurs in anterior poliomyelitis, multiple neuritis, and hysteria.
4. Flaccid paralysis of lower half of body results from section of spinal cord.
5. *Spastic Paralysis*—Upper motor neuron type. Increased reflexes, stiff muscles, spastic gait. Hemiplegia, paraplegia, lateral sclerosis, pernicious anemia, Wilson's disease.
6. *Ataxic Paralysis*.—Due to loss of deep sensibility, rather than to paralysis of muscles. Reflexes absent, Romberg positive, loss of vibratory sense. Tabes dorsalis, pernicious anemia, Friedreich's ataxia, cerebellar ataxia, neuronitis.

C. MUSCULAR IRRITABILITY.—

1. *Tics*.—"If these movements can vary in form from one individual to another, they nevertheless present some general characteristics which are the same in all cases. One of these characteristics is the suddenness with which it appears and the rapidity with which it is executed. All of a sudden while nothing in the general habitus of the patient makes one suspect anything in particular, a grimace, a contortion is produced, once, twice, repeated several times, then all is back in order again. But soon after, because generally the intervals are very short, renewed jerks follow." (Gilles de la Tourette: *L'Incoordination Motrice*, Paris, 1885.)
2. *Tremor*.—Trembling. Involuntary, rapid contraction and relaxation of muscles. Note whether it is continuous, or can be observed without re-enforcement, is brought out only on intentional movement, or by placing the limbs in a fixed position.
 - a. *Dyskinesia*, continuous or brought on at intervals, but evident to observer. Parkinson's disease, paralysis agitans, post-encephalitic syndrome, Huntington's chorea.
 "The agitation of the limbs and indeed of the head and the whole body was too vehement to allow it to be designated trembling." (Parkinson, 1817.)
 - b. *Intention tremor*.—"The tremor only manifests itself on the occasion of intentional movements of some extent: it ceases when the muscles are abandoned to complete repose." (Charcot, J. M.: *Lectures on the Diseases of the Nervous System*, London, 1877, p. 157.)
 - c. *Brought out by re-enforcement*.—Exophthalmic goiter. Neurasthenia. Alcoholism. "In testing for tremor, the patient is directed to stretch out the arms with the fingers extended and separated as widely as possible. The difficulty becomes at once apparent, or is felt as a thrill by the examiner's hand placed against the finger tips of the patient." (Church, Archibald, and Peterson, Frederick: *Nervous and Mental Diseases*, Philadelphia, W. B. Saunders Co., 1922.)
3. *Athetosis*.—Continuous or seldom interrupted, slow writhing movements of face, limbs, and entire body. Cerebral diplegia, postencephalitic syndrome.
4. *Chorea*.—St. Vitus's dance. "The Patient is unable to keep still for a single minute. If a cup of liquid is placed in his hand before he can bring it to his lips he goes through gesticulations like a contortionist." (Thomas Sydenham: *Processus Integri*, 1686.) Huntington's chorea (see p. 590).
5. *Convulsions*.—A convulsion is an involuntary generalized muscular paroxysm, usually of sudden onset and usually accompanied by loss of consciousness. Atonic convulsion is contraction of the muscles

without relaxation, a clonic convulsion is alternate contraction and relaxation of opposing groups of muscles.

6. *Nystagmus*.—Rhythmic movements of the eyeballs—usually lateral, sometimes vertical or rotatory.
7. *Meningismus*.—Rigidity of spinal muscles, retraction of head on back, spasm of limbs.

Kernig's sign. (See p. 276.) (Neck.)

8. *Opisthotonos* is due to rigid spasm of the muscles of the neck, back, and legs, so that an overextended position of the entire body results. The posture of the patient may be lying on the side or with ventrum up and back down so that the body is resting on the occiput and heels (this occurs only in hysteria). *Opisthotonos* may be maintained for some time (in meningitis it is likely to be continuous), or periodic when spasm comes on (as in strychnine poisoning or tetanus). Uremia can produce it.

9. *Muscular Spasm*.—

- a. *Myotonia*—inability to relax muscle after voluntary contraction. The patient shakes hands, but cannot unloose his grasp from your hand.

- (1) *Thomsen's disease* (myotonia congenita)—apparently will develop, but really weak musculature, with myotonia of hands and legs. When starting to walk, cannot get the stiffened muscles to move, so stands rigid.

- (2) *Dystrophia myotonica*—atrophy of facial, sternomastoid, upper arm and leg muscles with myotonia, particularly of the hand.

- b. *Paramyoclonus multiplex*—clonic contractions of skeletal muscles. For this and other rare similar conditions see p. 587.

- c. *Torticollis*—spasm of one sternomastoid.

- d. *Occupational cramps*—writer's, telegrapher's cramp.

- e. *Tetany*—involuntary contraction of the muscles mostly of the face and arm, sometimes spontaneous and more or less continuous, usually requiring maneuvers to elicit.

Chvostek's sign.—Mechanical irritability of the nerves and muscles so that even the lightest touch over the nerves of the extremity elicits a twitching of the innervated muscles. The mechanical irritability of the branches of the facial nerve are markedly increased. (Chvostek: *Wien. med. Presse* 17: 1201, 1876.) Usually elicited by pressing or tapping over the malar bone, just anterior to the tragus of the external ear, which throws the facial muscles into spasm.

Trousseau's sign.—Compression of the arm, as with a blood pressure cuff, causes a slow contraction of the fingers and hand to a position of extreme flexion.

f. *Atrophy, dystrophy, pseudohypertrophic dystrophy.*—(1) *Face.*—

- (a) *Facial hemiatrophy* (including tongue).
- (b) *Myasthenia gravis.*—Begins with easy fatigability and goes on to permanent muscular weakness. Face looks drooped and tired. Patient can talk or chew a while and then stops from fatigue. Associated with congenital defects (fingers, mammary glands, genitals).
- (c) *Face, shoulder girdle, and arm.*—
 - i. *Facioscapulohumeral dystrophy of Landouzy-Dejerine.*—Atrophy of muscles of face and shoulder girdle.
 - ii. *Erb's progressive muscular dystrophy.*—Shoulder girdle and arm atrophy predominate. Some muscles show atrophy, some show pseudohypertrophy.
 - iii. *Syringomyelia* (scapulohumeral atrophy)—rare.

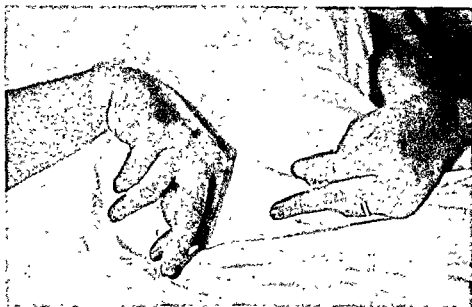


Fig. 65.—Tetany after thyroidectomy.

(2) *Hand.*—

- (a) *Amyotrophic lateral sclerosis.*—Thenar and hypothenar depression at base of thumb and wasting of interossei.
- (b) *Spinal progressive muscular atrophy of Duchenne-Aran type* (sporadic, associated with laborious occupation), or *Werdnig-Hoffmann type* (heredofamilial).
- (c) *Progressive muscular atrophy of Charcot-Marie type*—atrophy of small muscles of the hand—claw hand. Later atrophy of muscles of the forearm. But usually affects feet and legs alone. (See below.)

- (d) *Syringomyelia*—claw hand, skeletal atrophy, many forms of atrophy. Onset in early adult life.
- (3) *Pelvic girdle and thigh muscles*.—
- (a) *Atrophic type of Leyden-Moebius*.
- (b) *Pseudohypertrophic type of Duchenne-Griesinger*.—Both begin in childhood. Child prone to fall and has difficulty in climbing stairs. Waddling gait. Lordosis. On rising from the floor, climbs up himself, using his hands and arms braced against legs to assume erect position.
- (4) *Leg*.—
- (a) *Peroneal type of neural muscular atrophy, of Charcot-Marie-Tooth* (same disease as under "Hand"). Feet and calf muscles gradually become useless; seldom goes above knees.

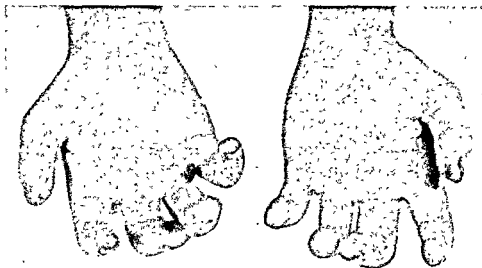


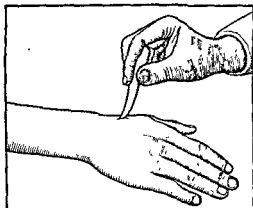
Fig. 66.—Progressive muscular atrophy.

- (5) *General*.—
- (a) *Dystrophia myotonica*—spasm of the muscles on voluntary movement with atrophy (differentiating it from the hypertrophy of Thomsen's disease) of the face, sternomastoids, muscles of forearm and quadriceps and dorsiflexors of the foot.
- (b) *Myotonia congenita of Oppenheim*. Onset from birth. Generalized small musculature with flaccidity. Stupid faces, but usually good intellect. Weakness of anterior neck muscles results in peculiar stooping posture and gaits. (See p. 586.)

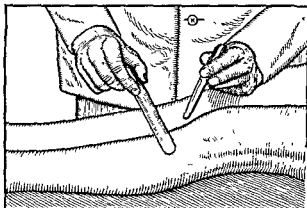
II. Sensation.—

A. TOUCH.—Skin sensation elicited with fine paint brush, wisp of cotton, or, best of all, a piece of paper.

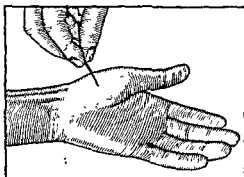
B. PAIN.—Deep pin pricks.



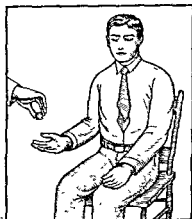
Sense of Touch



Temperature Sense



Testing for
Protopathic
Sensibility



Testing
Stereognostic
Sense

Fig. 67.—Examination of the nervous system for sensation.

C. TEMPERATURE.—With two test tubes, one filled with cold, one with hot water, touch the skin and ask patient with his eyes closed to decide which is which.

D. SPECIAL SENSES:

1. *Taste*:

Use solutions or powder to determine the four elementary taste sensations: with the patient's eyes closed place on tongue with glass rod:

Sweet—sugar solution. Salt—salt solution.

Bitter—quinine powder. Sour—vinegar.

2. *Hearing*.3. *Sight*.4. *Vestibular sense*.

E. DEEP SENSATIONS:

1. *Pallesthesia*.—Response to tuning fork vibrations.

2. *Stereognostic Sense*.—With eyes closed, put a coin, a key, in the patient's hand and ask him to tell what the object is.

3. *Bathyessthesia*—sense of position, sense of movement. With patient's eyes shut, place big toe in flexed and extended position and ask patient to tell where it is, etc.

III. Coordinated Functions.—

A. COORDINATED MUSCULAR CONTROL.

Romberg's sign.—“If the patient is asked to close his eyes while standing upright, he immediately begins to sway and reel.” (*Lerbuch der Nervenkrankheiten des Menschen*, Berlin, 1849.)

Button—unbutton coat.

Heel—knee.—Touch heel to knee with eyes closed.

Finger—nose.—Touch finger to nose with eyes closed.

Adiadochocinesis.—Patient is asked to pronate or supinate either forearm in the quickest possible succession. (The last three tests are “cerebellar signs.”)

B. GAIT.

Ataxic.—“The gait begins to be insecure and the patient attempts to improve it by making a greater effort of the will; as he does not feel the tread to be firm, he puts down his heels with greater force. From the commencement of the disease, the individual keeps his eyes on his feet to prevent his movements from becoming still more unsteady.” (Romberg, *vide supra*.)

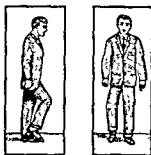
Steppage.—Foot drop, due to peroneal palsy in multiple neuritis, alcoholic neuritis, and old poliomyelitis.

Hemiplegic.—“The patient supports himself on the sound limb, draws the paralyzed one after him and circumducts it, the foot itself describing a half circle around the resting leg as an axis. He cannot lift his toes from the floor.” (Oppenheim: *Diseases of the Nervous System*, 1900.)

Spastic, paraplegic.—“Each foot is removed from the ground with difficulty and in the effort which the patient then makes to raise it and



Tabetic Gait

Steppage Gait
Multiple Neuritis

Paraplegic Gait



Hemiplegic Gait

Gait of
Paralysis AgitansGait of
Cerebellar Ataxia

bring it forward, the body is straightened and thrown backwards, as though to counter-balance the weight of the lower extremity, which before being placed on the ground is seized with involuntary trembling. During these movements of progression, the point of the foot is sometimes depressed and drags more or less along the ground before being raised." (Ollivier, 1827.)

1 Parkinsonian.—"A propensity to bend the trunk forwards, and to pass from a walking to a running pace." (James Parkinson: *Essay on the Shaking Palsy*, 1817.)

Cerebellar ataxia.—"The gait is that of a man half asleep, staggering and uncertain, not made worse by shutting the eyes. This has no relation to the muscular force, which is good enough." (Duchenne, 1854.)

C. POSTURE:

Standing.

Sitting.

Recumbent (meningismus).

D. SPEECH:

Stuttering.

Aphasia.

Slurring consonants.—Test phrase: "God save the Commonwealth of Massachusetts."

Scanning.—"A symptom more frequently found than nystagmus, in multiple sclerosis, is a peculiar difficulty of enunciation—the words are as if measured or scanned, there is a pause after every syllable, and the syllables themselves are pronounced slowly." (Charcot, 1877.)

E. WRITING.

F. SWALLOWING.

G. BLADDER AND RECTAL CONTROL.

IV. Mental State.—

A. DEPRESSED.—Melancholia, stupor, coma.

B. DISORIENTED.—Illusions, hallucinations.

C. EXCITED.—Delirium, mania.

MINIMUM EXAMINATION FOR MENTAL STATUS (5 MINUTES)

The mental status of the patient can be gathered by the physician during the physical examination. In some circumstances, as in examining for employment, such an opportunity is not afforded and a brief questionnaire, deliberately designed to determine mental status is employed. The following is one used by Dr. Calvert Stein in examining recruits, and found satisfactory. (New England J. Med. 224: 920, 1941.)

Ask some of the questions casually while doing the neurological examination. Thus:

The patient sits and extends his legs for knee jerks while the examiner asks, "How far did you go in school?" A maximum of sixth grade (normally

completed at eleven or twelve years) or less, without adequate excuse (illness, necessity to go to work and so forth) suggests intellectual retardation.

The tendon reflexes of the forearm are checked as the next question, "What have you been doing since you left school?" is propounded.

Then the questionnaire continues with the applicant seated at ease:

"How do you feel?

"Do you eat well?

"How do you sleep?" (Sleep and digestion are impaired first in neurotic persons.)

"How are your stomach and your bowels?

"Are you taking any medicine?

"Do you have any aches or pains?

"Does anything bother you?

"How do you get along with girls?" (If married . . . with your wife?)

"What is the longest time that you have spent on any one job?" (A large number of jobs in a very short time may suggest simple schizophrenia or a psychopathic inadequacy.)

"How do you feel about this job?"

Rough psychometric tests for suspected mental retardation:

"Repeat six digits forward (twelve-year test, Stanford).

"Repeat five digits reversed (twelve-year test, Terman-Merrill).

"Give an acceptable definition—not too technical—of the abstract words, 'constant,' 'courage,' 'charity,' 'defend' (Terman-Merrill).

"Name some rivers, cities, and mountains in your home state."

Similarities (eleven-year test, Terman-Merrill). The question is asked: "In what way are rose, potato, and tree alike?" The same question for knife-blade, penny, piece of wire, or wool, cotton, and leather, and for book, teacher, and newspaper.

DISEASES OF THE NERVOUS SYSTEM

I. DISEASES OF THE MOTOR SYSTEM

A. Paralysis of Peripheral Nerves

FOREHEAD.—The occipitofrontalis is innervated by the seventh cranial or facial nerve. Inability to wrinkle the forehead occurs in peripheral paralysis of the seventh, in polyneuritis (Yndelson: Facial Diplegia in Multiple Neuritis, J. Nerv. and Mental Dis. 65: 30, 1927, and Viets: Acute Polyneuritis With Facial Diplegia, Arch. Neurol. and Psychiat. 17: 794, 1927), in myasthenia gravis, and in hysteria.

MUSCLES OF MASTICATION.—The masseter, temporal, and pterygoid muscles are supplied by the inferior maxillary division of the fifth cranial or trigeminal nerve. Paralysis seldom occurs. When it does occur, it is usually a complication of otitis. One-sided paralysis results in an inability to move the jaw sideways in one or the other direction. Asynergic mastication occurs in cerebellar lesions. Buccinator palsy is due to seventh nerve paralysis.



Third Cranial Nerve.
Ptosis



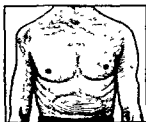
Sixth Cranial Nerve.
Right External Rectus



Seventh Cranial Nerve.
Left Facial Paralysis



Right
Musculo-Spiral Nerve.
Wrist Drop



Right Circumflex Nerve.
Deltoid Palsy and Wasting



Ulnar Nerve.
Claw Hand



Serratus Magnus
Palsy



Right Peroneal Nerve.
Foot Drop

FACIAL.—The seventh nerve supplies the orbicularis palpebrarum, frontalis, corrugator supercilii, zygomaticus, nasal muscles, orbicularis oris, risorius, depressor anguli oris and depressor labii inferioris, and platysma. Paralysis results in inability to wink, or rather screw up the eye tightly, lacrimation, one-sided facial paralysis, asymmetry of the face at rest. If the lesion be within the Fallopian aqueduct below the geniculate ganglion, so as to involve the chorda tympani, it produces besides the paralysis noted above, loss of taste in the anterior two-thirds of the tongue, and painful sensations of hearing.

If the nucleus of the seventh is diseased, there is facial paralysis, no taste or auditory disturbance, but the sixth nerve paralysis (*vide infra*) is likely to be added on account of the proximity of the two nuclei.

The cause of seventh nerve paralysis is either (1) involvement of the nerve during its course through the temporal bone, due to middle ear or mastoid disease or skull fracture; or (2) causes vaguely called rheumatic, catching cold, etc. The first is likely to be permanent, the second runs a course to recovery in about ten weeks, but is likely to recur. Central or nuclear destruction with facial palsy is rare: the causes are diphtheria, poliomyelitis, encephalitis, and tumor. The most frequent tumor is leucemic chloroma, associated with chloroma elsewhere in the body.

In cortical lesions (hemiplegia) the facial muscles are not usually involved. If they are, it is nearly always the lower contralateral muscles, the upper face with emotional movements remaining intact.

Facial diplegia, paralysis of facial muscles on both sides, is rare, usually due to syphilitic basilar meningitis.

In differential diagnosis only facial hemiatrophy is likely to confuse. This rare disease, which is progressive, beginning in childhood and causing one-sided atrophy of the face and tongue, is probably due to a central involvement of some parts of the fifth nerve. (Woltman: Facial Paralysis, M. Clin. North America 3: 557, 1919.)

Ptosis.—The third cranial or oculomotor nerve innervates the levator palpebrarum. Ptosis resulting from syphilitic disease of the oculomotor nerve is the commonest cause; it is often associated with paralysis of the internal, superior, and inferior recti, with external strabismus, dilatation of the pupil and inability to move the eyeball up or down. The underlying pathology is a gummatous meningitis in most cases. Hysteria, myasthenia gravis, tuberculous meningitis, tumors of the corpora quadrigemina, or of the tegmental region of the crus or pons (Benedict's syndrome is due to tumor involving the red nucleus and consists of ptosis on the side of the lesion, with slow rhythmic tremor of ptosis on the side of the lesion, with slow rhythmic tremor of the limbs of the opposite side), encephalitis, are other organic causes. General body weakness will cause ptosis. It is an element in the facies which we note as indicating real illness. The neurasthenic is ptotic in the morning. The levator palpebrarum has also innervation from the autonomic nervous system.

Horner's syndrome consists of ptosis, constriction of the pupil, and shrinking of the eyeball into the orbit (enophthalmos). There is associated heat, redness, and edema of the face on the same side. Horner's description was:

"The patient noticed a gradual drooping of the right upper eyelid . . . the pupil of the right eye was found to be definitely smaller than that of the left, the eyeball very slightly sunken. . . . While the case was under observation, there developed before our eyes gradually increasing redness and heat of the right half of the face, although the left half remained pale and cold. . . . The patient then told us for the first time that she had never perspired on the right side. . . . I believe . . . that this gradually developing, but never complete, ptosis should be regarded as a paralysis of the superior palpebral muscle, which is supplied by the sympathetic." (J. F. Horner: *Klin. Monatsbl. f. Augenh.* 7: 193, 1869.)

Injury to, or disease of, the brain stem, the lower part of the cervical or upper part of the dorsal portion of the spinal cord or its nerve roots, the superior cervical sympathetic ganglion or the postganglionic nerves locate the seat of changes that result in Horner's syndrome.

Miosis is the most constant factor. The pupil reacts weakly to light and accommodation, but does not respond to the installation of cocaine. The ptosis is not true, but pseudoptosis; the eyelid can be raised voluntarily. The enophthalmos is not explained. Perhaps it is due to palsy of the retrobulbar muscle of Müller, perhaps to trophic disturbances, associated with decrease of orbital fat. There is even question whether it is real enophthalmos or not, the narrowing of the palpebral fissure giving an illusion of enophthalmos. Wagener (*Am. J. Ophth.* 17: 209, 1934) could demonstrate enophthalmos by the exophthalmometer in only one out of ninety-five cases.

The other symptoms, heat, anhidrosis, etc., are less constant.

The commonest causes are tumors of the spinal cord, or syringomyelia at the level of the ciliospinal center. Next are cervical rib, cervical tumor, or enlarged lymph nodes, aortic aneurysm, tumors of the upper mediastinum, disease of the pulmonary apices, disease of the esophagus and adenoma of the thyroid. It follows trauma, especially stab wounds of the neck, thyroidectomy, and operations on the phrenic nerve. (See De Jong: *Horner's Syndrome*, *Arch. Neurol. and Psychiat.* 34: 734, 1935.)

Oculomotor paralysis naturally accompanies ptosis when there is organic disease of the third nerve. Involvement of the third nucleus produces ptosis, usually without recti palsy. Injuries to the skull may produce paralysis of the external rectus alone.

The fourth nerve, abducens, is often injured when the skull is fractured, sometimes by sinus thrombosis or otitis media, or brain abscess. Trochlear paralysis does not cause an obvious strabismus, but a diplopia occurs in every direction in which the eyes are turned except upward.

The sixth nerve innervating the external rectus is, on account of its long course across the base of the skull, subject to encroachment by gumma of the meninges, or cavernous sinus thrombosis and hemorrhage into the dura following injury. Double sixth nerve paralysis is always evidence of a pontine tumor.

Erosion of the tip of the petrous bone from otitis media may cause Gradenigo's syndrome. The process involves the abducens nerve and the Glasserian

ganglion—parietotemporal and orbital headache, diminished or absent corneal reflex, paresis of the lateral rectus (trochlear nerve).

Unilateral paralysis of oculomotor, trochlear, and abducens may result from lesions involving the cavernous sinus, the bony wall at the angle of the orbit or near the superior orbital fissure. If the ophthalmic branch of the fifth nerve is involved, the syndrome of Fox results, a lesion in the lateral wall of the cavernous sinus, causing ophthalmoplegia III, IV, V, VI, beginning with the sixth.

Central lesions of the anterior part of the midbrain (encephalitis or pineal tumor) may result in disturbance of the muscles of the eye (Parinaud's syndrome) hemianopia, and paralysis of vertical gaze.

Increased intracranial pressure caused by the growth of an intracranial tumor causes unilateral sixth nerve paralysis. It was once considered a localizing sign, but Cushing showed that it is a general sign of pressure (Brain 33: 304, 1910-1911). The transverse branches of the basilar artery generally overlie the nerves and, as intracranial pressure rises, constrict them. Fluctuations in the pressure account for the otherwise puzzling fluctuations in the paralysis.

The pharynx muscles are innervated by the glossopharyngeal and the vagus. Injury, either peripheral or central, results in paralysis of the palate, pharynx, and larynx. If bilateral (bulbar paralysis), there is difficulty in swallowing, and dyspnea, stridor, and aphonia. If unilateral, there is little difficulty in swallowing because of interlacing muscle fibers projecting over from the contralateral side of the pharynx; nasal voice resonance and some aphonia are present. Stab wounds or bullet wounds in the neck do not result in vagus palsy alone, because it is so intimately associated with the sheath of the carotid artery and jugular vein that such an injury would result in immediate death from hemorrhage. It is affected in tabes, and by poisons such as carbon monoxide, phosphorus, lead, arsenic, and excessive amounts of morphine, atropine, and alcohol. The recurrent laryngeal branch is subject to isolated injury by aneurysm, mediastinal lymph nodes, goiter, and mitral stenosis.

The glossopharyngeal (ninth cranial) is so seldom injured or diseased alone as to be a negligible factor.

Unilateral paralysis of the pharynx is determined by watching the throat while the patient says, "Ah!" Normally the raphe rises. But if one side of the palate be paralyzed, the healthy side alone pulls upward, and the raphe deviates to the sound side, forming a characteristic dimple. Laryngeal paralysis can be made out with the laryngoscope: in inspiration the paralyzed side remains flaccid in the midline, while the sound side is pulled open; in phonation the sound side is tense, pushing the paralyzed side beyond the midline.

In total paralysis of the vagus there is also anesthesia of the palate, the pharynx, and the larynx.

THE TONGUE.—The hypoglossal (twelfth cranial) nerve innervates the tongue. Paralyzed half of tongue becomes wrinkled and atrophied. When the tongue is protruded, the healthy side causes the tip to be pushed around to the paralyzed side in a sickle-shaped curve.

Causes of hypoglossal paralysis are most commonly central, such as bulbar palsy, syringobulbia, etc. In such circumstances the paralysis of the tongue is bilateral, and accompanied by the wrinkled appearance of atrophy. Fibrillary twitchings precede paralysis. The orbicularis is often simultaneously involved because the fibers passing by way of the seventh nerve to innervate this muscle have their origin in the hypoglossal nucleus. With bilateral paralysis of the tongue, there is serious difficulty in speaking and eating. The tongue falls to the floor of the mouth. In unilateral paralysis, on account of the interlacing muscles, eating and speaking are not seriously impaired.

Peripheral injury to the nerve may be by stab or bullet wounds below the jaw. Purulent inflammation of the throat may involve the nerve trunk.

THE SHOULDER.—The deltoid muscle is supplied by the circumflex nerve. With paralysis the rounded contour of the shoulder is lost and the arm cannot be raised laterally, forward or backward.

Serratus magnus palsy from lesion of the long thoracic nerve results in inability to raise the arm above the horizontal plane. When the arm is raised, the shoulder blade flares out—*winged scapulae*.

Infraspinatus and supraspinatus palsy are due to lesion of the suprascapular nerve. There is loss of external rotation of the arm, and atrophy of the muscles over the scapula.

The commonest form is Erb's birth palsy. This is caused by traction on the neck in a forceps delivery or other difficult delivery. The subclavian nerve, arising from the fifth and sixth cervical roots, is ruptured or injured. This produces a paralysis of the muscles only of the upper arm and shoulder, with the exception of the supinators. The child, shortly after birth, is seen to hold the arm limp at the side in a position of adduction and internal rotation, in the position made familiar by vaudeville comedians of the "policeman's tip"—the palm shoved behind to accept the bribe. Differential diagnosis should consider the powerless arm of a newborn baby due to separation of the epiphysis of the head of the humerus, or fracture of the clavicle. (See Boorstein: *Obstetric Brachial Palsy*, J. A. M. A. 82: 862, 1924.)

The spinal accessory (eleventh cranial) nerve supplies the sternomastoid and part of the trapezius. Paralysis results in downward and outward displacement of the scapula. The sternomastoid no longer stands out on rotation of the head to the opposite shoulder. (On account of double innervation of the sternomastoid from second cervical, it is not usually completely paralyzed.) Torticollis is not usually due to disease of nerve. When the shoulders are braced, the scapula is imperfectly approximated to the midline, and the rhomboids become visible subcutaneously.

The biceps is innervated by the musculocutaneous nerve. Paralysis is very rare.

THE HAND.—Wrist drop is caused by paralysis of the musculospiral (or radial) nerve supplying triceps, brachialis anticus, brachioradialis, and extensor carpi radialis. It is usually due to fracture of the humerus, wounds of the arm, etc.: the nerve may be caught in the callus of a uniting fracture. (McAusland and McAusland: *Am. J. M. Sc.* 169: 1, 1925.) It may be injured by pres-

sure of a crutch or abduction of the arm during surgical operation. Sleep palsy from hanging the arm over a bench occurs not infrequently but is usually temporary. Bilateral palsy is due to alcohol or lead poisoning.

Claw-hand is caused by paralysis of the ulnar nerve, involving the flexors of the proximal phalanx, the lumbricales and extensors of the distal phalanges. The nerve is easily injured in stab wounds, etc. The thumb paper test (*signe de journal* of Froment-Pressé medicale, Oct. 21, 1915) is performed by asking the patient to grasp a sheet of paper in both hands by the thumb and forefinger and pull it apart. On the sound side the whole length of the thumb is in contact with the paper, compressing it against the index finger, the terminal phalanx of the thumb being extended. On the paralyzed side only the thumb-tip presses the paper, with the terminal phalanx markedly flexed by the action of the flexor pollicis longus, innervated by the anterior interosseous nerve, a branch of the median.

In ulnar paralysis there is anesthesia of the little finger and half the ring finger and the corresponding part of the hand. Tardy paralysis of the ulnar nerve has developed as long as thirty-six years after the injury in cases of fracture at the elbow joint; the essential etiologic factor is the deformity and malposition of the elbow joint. (Ramsay Hunt: J. A. M. A. 66: 11, 1916.)

Syringomyelia produces a typical claw-hand deformity with atrophy ("main en griffe") exactly similar to an ulnar lesion. It also produces simple wasting, skeletal hand, and permanent contraction in dorsal flexion—preacher's hand.

The median nerve supplies the pronator radii teres, flexor carpi radialis, palmaris longus, flexor sublimis digitorum, flexor longus pollicis, flexor profundus digitorum, pronator quadratus. Paralysis results in weakness of flexion of the wrist, deviation of the hand to the ulnar side when flexion at the wrist is carried out against resistance, inward rotation of the arm when pronation of the forearm is attempted, no movement of thumb and forefinger when clenching the fist is attempted (only the three outer fingers clench).

Sensory changes are severe and profound, involving the palm of the hand, the thumb, index, middle, and half the ring finger. Vasomotor and trophic changes are also marked, producing glossy skin and tough, ridged nails. A cutting injury is the usual cause of isolated nerve paralysis.

THE LEG.—Quadriceps paralysis of the great muscles of the upper leg is due to disease or injury of the anterior crural nerve or femoral nerve. Neither flexion at the hip nor extension at the knee can be carried out. Walking is difficult. The leg is used as a stilt. The patient pushes back the knee to make it stiff.

THE FOOT.—Foot drop is due to paralysis of the anterior tibial or deep peroneal nerve, a branch of the sciatic. The toes are flexed. Results in steppage gait. There is anesthesia over the outer surface of leg and dorsum of foot. If the sciatic is injured or severed, there is not only foot drop but wasting of the leg, especially the gastrocnemius. As part of alcoholic multiple neuritis, or lead, these syndromes are common.

Sphincter Paralysis (buttocks, perineal region).—Cauda equina injuries result in paralysis of all the muscles of the lower limb with anesthesia below the folds of the groin in front, including the genitals, below the upper part of the buttocks, with loss of bladder and rectal control. If the first, second and third lumbar roots escape, the anesthesia is less extensive, and the paralysis spares the quadriceps, leaving the knee jerk intact, with loss of ankle jerk. A lower lesion involving mostly the sacral roots, results in no paralysis of the lower limbs, but the characteristic "saddle" anesthesia, an area on the buttocks, perineum, scrotum, penis, and a small strip down the internal aspect of the thigh. There is bladder and rectal sphincter paralysis.

Nerve disturbances due to spina bifida. (See p. 296.)

Neuritis is a term used of late for a group of conditions in which peripheral nerves, nerve roots, and spinal meninges are involved. It is probably due to some form of virus infection. As originally described by Guillain, Barré, and Strohl (Bull. et mém. Soc. méd. d. hôp. de Paris 40: 841, 1916) it is "A syndrome characterized by motor disturbances, loss of tendon jerks, preservation of cutaneous reflexes, paresthesias, tenderness of pressure of the muscles, little changes in the electrical reactions of the muscles or nerves, noteworthy hyperalbuminosis of the cerebrospinal fluid, in the absence of cytologic reaction. This syndrome seems to us to result from a concomitant attack on the spinal roots, nerves and muscles, probably by an infectious or toxic agent. The prognosis does not appear to be extremely serious."

The symptoms will depend on the location of the inflammation. One patient had cramping of the toes first, drawing sensation and numbness of the hands, momentary dizziness when rising from a reclining position. He had positive Romberg, ataxia, loss of tendon reflexes, and vibratory sense. In another there was rigidity of the neck, in another, pain in the abdomen and numbness in the hand. The high protein content of the spinal fluid, low cell count, and good prognosis are cardinal features. (See Guillain: Arch. Neurol. and Psychiat. 36: 975, 1936, and Bassoe: Arch. Path. 26: 289, 1938.)

SYNDROMES OF CENTRAL LESIONS CAUSING CRANIAL AND PERIPHERAL NERVE DISTURBANCES IN THE HEAD, NECK, AND SHOULDER REGION

These syndromes are combined motor and sensory disturbances. They fall into definite symptom groups, depending on focal lesions in the pons and medulla. They may be due to thrombosis of an artery—cerebellopontine, anterior spinal, basilar artery—or to syringomyelia or multiple sclerosis. Sometimes they are due to gumma or tumor, but these do not, obviously, pick out a given area, which would result in a definite syndrome as particularly as does the closure of an artery.

The symptoms may develop gradually or, as would be in the case of thrombosis or embolism of an artery, suddenly with coma, generalized tonic movements of the extremities and facial musculature. The residual symptoms become evident within a few days or weeks.

Lesions below where the pontine fibers commence to cross above the level of the tenth and twelfth nuclei produce the syndromes of Jackson, Avellis,

Babinski and Nageotte. Above this level are the syndromes of Millard-Gubler, Foville, Weber, and Benedict.

Thrombosis of the anterior spinal artery on one side or the other produces a one-sided internal lesion close to the midline at the level of the twelfth nucleus, involving the median lemniscus (sensory fillet) and the pyramidal tract (motor). There is consequently hemiplegia and hemianesthesia (especially of deep sensibility) on the opposite side of the body and hemiatrophy of the tongue on the side of the lesion with deviation of the tongue to that side.

The lesion is, however, usually bilateral. Syphilis is often to blame, so that the patients may be relatively young. The onset may be sudden or gradual, but nearly always reaches the climax in a few hours or days. Strain, effort, or trauma may be precipitating factors: a case reported by Grinke and Guy was that of a boy aged fifteen, who had no other etiology than vigorous yawning. The pyramids and lemniscus are involved on both sides, resulting in both motor and sensory symptoms: a tetraplegia of the spastic type with increased reflexes, clonus, and Babinski, etc., in the lower limbs, and Hoffmann reflex in the upper (flexion of the terminal phalanx of the thumb when the terminal phalanx of the middle finger is snapped between the thumb and index finger of the examiner), and on the sensory side, loss of sense of position, of passive motion and of vibration, especially in lower limbs, less frequently in the upper. There are also signs of involvement of the cervical cord with atrophy and flaccidity of segmental muscle groups about the shoulders, arms, and hands. Spontaneous pain often occurs at the outset. If the hypoglossus nucleus is involved, considerable improvement occurs in the course of a few months, especially if antisyphilitic therapy is indicated and applied early. (Ornstein: Thrombosis of the Anterior Spinal Artery, *Am. J. M. Sc.* 181: 654, 1931.)

The syndrome of Avellis is due to lesion or destruction in the retro-olivary bulbar region. There is hemianesthesia of the syringomyelic type (analgesia and thermoanalgesia) on the opposite side of the body, anesthesia of the face on the side of the lesion from destruction of the descending root of the trigeminus.

The syndrome of Jackson may go with this if the destruction is more widespread; hemiparesis of the pharyngo-laryngo-velo-palatine areas (the palate deviates away from the side of the lesion, the vocal cord on the side of the lesion remains fixed on phonation, and the side of the tongue on the side of the lesion is anesthetic), with or without oculopupillary vegetative signs, with or without concomitant alternate paralysis of the twelfth cranial and lower parts of the eleventh. Later cerebellar hemiataxia and hemiasynergia are present from lesion of the bulbo-retro-olivary tegmentum supplied by the inferior and posterior cerebellar artery.

The Babinski-Nageotte syndrome (antero-internal retro-olivary bulbar) involves the crossed pyramidal tract and lemniscus, including the posterior longitudinal fasciculus and the restiform body and inferior cerebellar peduncle. There is hemiplegia and hemianesthesia for all forms of sensibility on the side of the lesion. There is hemiatrophy of the tongue from involvement of the

hypoglossus nucleus, paralysis of the pharynx and cord, myosis and narrowing of the palpebral fissure, hemianesthesia of the face from involvement of the fifth nucleus, on the side of the lesion, dysphagia and dysphonia and dizziness.

Thrombosis or occlusion of the basilar artery or the posterior inferior cerebellar artery produces fairly definite syndromes depending on the location of the lesion in the pons.

The anterior pontine syndrome of Millard and Gubler is due to a lesion which involves the pyramids, the sixth nerve, but usually not the seventh nerve, and it spares the lemniscus. There is hemilateral spastic paralysis of the opposite side of the body, with internal strabismus on the opposite side from the hemiplegia.

The *Millard-Gubler-Foville* syndrome, originally described by Foville, is usually vascular in origin, involving the vertebral, basilar, and middle pontine vessels. It involves the pyramids, lemniscus, sixth and seventh nuclei. There are hemiplegia and hemianesthesia (which may involve tactile or postural sense or all modes of sensibility) on the opposite side from the lesion, and strabismus (paralysis of the sixth nerve on the opposite side from the hemiplegia), paralysis of the lateral movements of the eye. Because of predominance of the antagonists, the patient has the eyes fixed toward the side of the hemiplegia.

Thrombosis of the posterior inferior cerebellar artery and/or of the vertebral artery are not uncommon forms of apoplecticiform seizures. The predominant signs are of bulbar palsy.

The posterior inferior cerebellar artery is the largest and longest branch of the vertebral artery. It supplies areas of the pons and sometimes medulla, and part of the cerebellum. The terminal (penetrating lateral) branches are end arteries so when occlusion occurs, the softening of the parts supplied is complete. Other branches anastomose freely, as do other terminal branches of the basilar artery, so their occlusion does not produce such clear-cut signs. The artery is subject to variability in its course (Bury and Stopford: *Med. Chron.*, Manchester 58: 200, 1913) and the syndrome of occlusion will vary, depending upon what pontine structures it supplies. Generally the restiform body, the hypoglossus nucleus, the central path of the sympathetic, the receptive nucleus of the glossopharyngeal and vagus, and the vestibular nucleus, the nuclei of the seventh, sixth, and auditory nucleus of the eighth may be involved.

The pyramidal tract, the medial lemniscus, the posterior longitudinal bundle, and the hypoglossal nerve and its nucleus are not supplied by the inferior posterior cerebellar, but the signs in certain cases look as if they were involved. Perhaps variability of the artery would account for this. More likely the syndrome described by Spiller (*J. Nerv. and Ment. Dis.* 35: 365, 1908) which he regarded as a complement to the posterior inferior cerebellar syndrome and in which occlusion of the upper branch of the anterior spinal artery or the vertebral artery is the real cause. These supply the pyramidal system of the medulla, the medial fillet or lemniscus, the posterior longitudinal bundle, and the hypoglossus nucleus or nerve. If these parts only are involved, it would indicate an occlusion of the upper branch of the spinal artery. If the examination shows that these parts are affected together with

those usually involved in occlusion of the posterior inferior cerebellar, the conclusion would be that the vertebral and not the posterior inferior cerebellar is involved.

This little artery next to the equally tiny lenticulo-striate artery is of major importance to the happiness of its owner. The syndrome is reported as if it were rare, but lack of acquaintance with, and recognition of, the syndrome undoubtedly plays a part, and in my experience many cases assumed to be cerebral apoplexy are of this origin.

The signs and symptoms of occlusion of the posterior inferior cerebellar artery can be divided into those on the same side of the body as the lesion in the medulla (A) and those on the opposite side of the body (B).

A.—1. Dizziness, vertigo, disturbance of equilibrium, falling to the side of the lesion, nystagmus, and in some cases diplopia. (These can probably be ascribed to involvement of Deiter's nucleus.)

2. Nausea and vomiting due to an irritation of the visceral vagal nucleus on the floor of the fourth ventricle.

3. Horner's syndrome (see p. 551) due to involvement of the sympathetic center and pathway in the medulla.

4. Usually diminution of cutaneous pain, heat and cold, severe in the distribution of one or more branches of the trigeminal nerve.

5. Aphonia, weakness and hoarseness of the voice, inability to swallow, due to involvement of the nucleus ambiguus.

6. Weakness on one side of the body, falling and walking to one side, hypotonia with diminished deep reflexes, ataxia, and past pointing are a result of involvement of the direct spinocerebellar tracts, or the restiform body, or both.

B.—1. Diminution or loss of pain and temperature sense up to the level of the distribution of the trigeminal in the face, with normal tactile sense in the same parts.

2. Dysesthesia, subjective sensations of tingling, stinging, heat or cold in the same area as (1).

3. Diminution or absence of the abdominal and normal plantar reflexes.

4. Tactile, muscular, joint, and vibratory sense are usually normal in all parts of the body.

The differential diagnosis between occlusion of the posterior inferior cerebellar artery and the vertebral artery cannot be made with certainty. There is so much variation in the arteries of this region that it is practically impossible to state always whether a clinical symptom complex is due to vertebral or to inferior cerebellar disease. Breuer and Marburg (Obersteiner's Arbeit 9: 181, 1902) reported a case in which the vertebral artery was occluded and the posterior inferior cerebellar artery escaped and yet the lesion occupied the same region as in cases where the posterior inferior cerebellar artery was occluded. If pontile symptoms are present, according to these authors, the vertebral artery rather than the posterior inferior cerebellar is probably the seat of the lesion.

Eighty-eight per cent of cases of thrombosis of either the posterior inferior cerebellar or vertebral arteries occur in syphilitics or alcoholics.

Peduncle Syndromes.—Lesions in the region of the upper level of the pons, lower border of the corpora quadrigemina and exit of third nerve give rise to syndromes as follows:

Weber's Syndrome.—Hemiplegia, oculomotor palsy (ptosis, divergent strabismus, sometimes mydriasis and fixed pupils), paralysis of face, tongue and uvula on the same side as the hemiplegia and, more rarely, conjugate deviation of the head and eyes.

Benedict's Syndrome.—Much the same as Weber's syndrome with added features. Besides the contralateral hemiplegia, there is a contralateral hemianesthesia and choreo-athetoid tremor from involvement of the red nucleus or rubrospinal and rubrocerebellar fibers.

The two syndromes above usually are caused by apoplexy and the onset is marked by coma, the residual paralysis showing up on recovery.

Nothnagel's Syndrome (Corpora quadrigemina or collicular syndrome).—Headache, vomiting, optic neuritis, dizziness, staggering gait, and mixed forms of oculomotor palsy. The conjugate vertical movements of the eye are involved, and there is often nystagmus. The pupils are widely dilated and show anomalous reactions to light and accommodation. Hearing is modified if the posterior quadrigeminal bodies are involved. The syndrome is usually due to tumor in the region of the corpora quadrigemina, perhaps of the pineal.

Raymond-Cestan, or Cestan-Chenais, syndrome is due to obstruction of twigs of the basilar artery and produces damage to the pyramidal tract, fillet, restiform body, and posterior longitudinal bundle. There is ipsilateral palatolaryngoplegia with asynergia of the extremities and contralateral oculogyric paralysis with dissociation of the eye movements, giving rise to temporary diplopia plus crossed spastic paralysis of the extremities and hemianesthesia. The syndrome of Tapia is due to implication of the nucleus ambiguus and hypoglossal nucleus. There is ipsilateral paralysis of the vocal cord and soft palate (laryngoplegia and palatoplegia) and ipsilateral paralysis with atrophy of the tongue (atrophic glossoplegia) and absence of all other motor and sensory symptoms. It occurs mostly in poliocencephalitis.

Flaccid Paralysis—Generalized

In the presence of paralysis of a muscle group or groups which do not correspond to the paralysis of a single peripheral or cranial nerve, and which is flaccid, the clinician must consider the following:

1. *Anterior poliomyelitis* (infantile paralysis) is an infectious, often epidemic, disease probably caused by a virus. The pathology of the disease is most frequently a degeneration of the motor cells of the anterior horns of the cord, in the cervical or lumbar region. The virus has a distinct affinity for nervous gray matter. The motor nuclei of the medulla and midbrain can be involved. The cerebral and cerebellar cortex and basilar ganglia are almost never involved. The lesions in the cord which are inflammatory sometimes extend beyond gray matter and involve the long fiber pathways, but this is most unusual.

Forty-seven per cent of the cases in the New York epidemic of 1931 were from 1 to 4 years of age, 29 per cent were from 5 to 9. The age incidence varies slightly in different epidemics. Adults are not immune, but after the age of 25, the incidence is about 0.1 per cent.

The onset is acute with fever, prostration, diarrhea, and gastric disturbances. After this febrile period, which lasts from several hours to two days, the paralysis, if any, becomes evident. During epidemics undoubted cases proceed to recovery without any paralysis, but without the paralysis they must always remain somewhat doubtful. After the febrile period, the maximum paralysis occurred in 30 per cent within twenty-four hours, in 33 per cent on the second or third day, and in 20 per cent on the fourth to sixth day. In the rest it was gradual in its extension. This typical mode of onset may be varied by one of pain in muscle groups and immediate paralysis, or paralysis and fever may be coexistent without pain. These meningeal types of onset are associated with Kernig and Brudzinski signs.

Wickman (Nerv. and Ment. Dis. Monograph 16, 1913) classified eight poliomyelitic syndromes:

1. Spinal form.
2. Landry's ascending type.
3. Bulbarpontine form.
4. Encephalitic.
5. Ataxic.
6. Neuritic.
7. Meningitic.
8. Abortive.

Diagnosis in the preparalytic stage is important because of the chance of early isolation, but except in the midst of an epidemic it is seldom accomplished. The examination of the spinal fluid furnishes the only significant diagnostic data. There is an excess of globulin and a moderate drop in chlorides. Early there can be seen a number of polymorphonuclear leucocytes and later an excess of lymphocytes. The cell count never reaches the proportion of that of meningitis. A count over 10 during an epidemic is almost pathognomonic, but counts of 2,500 can occur.

After paralysis has appeared, the diagnosis should not be in doubt. The distribution of the paralysis is

	PER CENT
One or both legs	50
Combination of arms and legs	15
One or both arms	7
Trunk alone	0.1
Trunk and either arms or legs, or combination	15
Whole body	3
Cranial nerves	2
Ascending paralysis	2
Spinal and cranial nerves	2

The ascending paralysis (Landry's) type begins in the feet and legs and spreads upward, finally terminating in respiratory failure and death. Sensory fibers may be implicated.

The bulbarpontine type may be unilateral or bilateral. The facial muscles are commonly affected, then in order of frequency, ocular muscles, speech and deglutition disturbances, tongue paralysis, and paralysis of the diaphragm and intercostal muscles.

The polioencephalitic type with involvement of the oculomotor, trochlear, and pyramidal tract is different from the spinal type in that it has a hemiplegic distribution.

The bladder and rectum are affected only on the rarest occasions.

In any suspected case the examiner should pay close attention to the cremasteric and abdominal reflexes.

2. Multiple Neuritis.—Infectious polyneuritis (Guillain-Barré syndrome) is the disease which even beyond encephalitis and meningitis is likely to be confused with acute poliomyelitis. The syndrome may follow nearly any infectious disease (see Rydeen and Glaser: *Ascending Myelitis Complicating Measles*, *J. Pediat.* 21: 374, 1942), but there is a form of unidentified etiology. Strauss and Rabiner (*Arch. Neurol. and Psychiat.* 23: 240, 1930) have described a form of myeloradiculitis, with rapidly developing motor and sensory symptoms and signs, with equally rapid improvement or recovery. The clinical similarity of the cases they observed leads them to believe in a common etiologic factor.

In most instances a flaccid paralysis of the lower limbs with absence of knee, ankle, abdominal and cremasteric reflexes, associated with a zone of hyperesthesia or hyperalgesia of radicular distribution somewhere on the body, not necessarily associated with the area of paralysis.

The differential diagnosis between infectious polyneuritis and poliomyelitis is not an academic problem in that the prognosis in infectious polyneuritis is good. (Although Forster, Brown and Merritt report a series of 26 cases with facial diplegia and a mortality of 42 per cent. *New England J. Med.* 225: 51, 1941.)

In infectious polyneuritis there is a slow progressive involvement, although the onset may be overwhelming. There is hyperesthesia, as well as the muscle pain characteristic of poliomyelitis. The paralysis is usually of a slowly ascending type. It is of the flaccid type with absence of tendon reflexes. The spinal fluid shows a normal cell count and increased protein. While it is unusual to have any new involvement after the second week of poliomyelitis, new paralyses may develop as late as one to three months after onset. (See DeLanctis and Green: *J. A. M. A.* 118: 1145, 1942.)

Diphtheritic polyneuritis begins at least two weeks after the onset of the diphtheria. In most cases the paralysis is localized and confined to the soft palate, with regurgitation of fluids through the nose when swallowing is attempted, and nasal speech. The vagus may be involved, resulting in tachycardia which has a fluctuating tendency. More generalized forms occur with

involvement of the extremities. The motor nerves are predominantly affected with signs of flaccidity, atrophy of the muscles, loss of deep reflexes, and reaction of degeneration. Next to acute poliomyelitis, the Landry syndrome of ascending paralysis is most often observed in diphtheritic polyneuritis. Recovery is the rule in the localized forms of diphtheritic paralysis, but the prognosis should always be guarded.

Multiple neuritis, not of infectious origin, is fairly strictly motor in character, although sensory symptoms are naturally not excluded. But what the laity calls neuritis, consisting of pain in muscle or nerve paths, does not come within the scope of the technical definition of neuritis. The motor nerves are more susceptible to degeneration than the sensory. Causes, aside from infections as described above, are chemical agents and metabolic deficiencies.

The commonest chemical agents responsible are ethyl and methyl alcohol, lead, arsenic, bismuth, trichlorethylene, and carbon monoxide.

The metabolic state with which we are chiefly concerned is beriberi, or multiple neuritis due to thiamine chloride (vitamin B) deficiency.

John Coakley Lettsom (Some Remarks on the Effects of Lignum Quassiae Amarae, Mem. Med. Soc. London, 1779) first described alcoholic polyneuritis thus: "The lower extremities grow more and more emaciated: the legs become as smooth as polished ivory and the soles of the feet even glassy and shiny and at the same time so tender that the weight of the finger excites shrieks and moaning; and yet I have known that in a moment's time, heavy pressure has given no uneasiness. The legs and the whole lower extremities lose all power of action; wherever they are placed, there they remain until moved again by the attendant. Thus for years they exist."

In Minot, Strauss and Cobb's series of alcoholic polyneuritis there were 107 males, 23 females; the ages varied from 23 to 68 years—average, 44.

The typical case of alcoholic neuritis is a peroneal palsy of the lower extremities, with ankle drop, steppage gait, and loss of tendon reflexes. Hyperesthesias and formication are usual premonitory signs. Arm palsy with wrist drop is the next commonest form; arm and leg palsy may go together, but classification is difficult because, as Jelliffe says, no two cases of alcoholic polyneuritis are alike. In the main it tends to run a subacute course and if untreated, reaches a stage of contraction and atrophy where use of the limbs is almost completely gone and the patient is confined to bed. *Korsakoff's syndrome* is delirium and mental disorientation with polyneuritis. *Wernicke's polioencephalitis hemorrhagica superior* is an alcoholic encephalopathy involving the midbrain with ptosis, tremor, rigidity, oculomotor palsies, convulsions, and psychosis.

Experiments by Strauss have shown quite conclusively that alcoholic polyneuritis is not due to a specific toxicity of ethyl alcohol for the nerves, but is in reality beriberi, or vitamin B₁ deficiency induced by the alcoholic's habitual refusal of food. He gets his calories in his drink, and as he has an accompanying gastritis anyhow, he eats little or nothing while he is drinking heavily. Strauss (Am. J. M. Sc. 189: 378, 1935) performed the crucial and convincing experiment. He permitted ten patients with alcoholic polyneuritis to continue

their customary intake of liquor (one pint to one quart daily) but forced them to eat well-balanced meals fortified with vitamin B₁ concentrates. The rapidity of their recovery from the paralysis was as great as in the control group from whom alcoholic drinks were withdrawn. Minot-Strauss and Cabot found that 21 of their 43 patients had no acid on gastric analysis, and 15 had a diminished secretion; only 7 secreted normal acid. James Jackson in his classic paper, "On a Peculiar Disease Resulting From the Use of Ardent Spirits" (New England J. Med. and Surg. 11: 351, 1822) noted that "The appetite is lost or is morbid and constipation and diarrhœa take place" and he found for treatment "animal food most useful."

Methyl alcohol has a distinct affinity for the optic nerve. Scott, Heltz and McCord (Am. J. Clin. Path. 3: 311, 1933) made animal experiments to study the histopathology and found that the lesions were degenerative ones and affected parenchymal and neurone tissues only in both retina and optic nerve.

Jamaica ginger (Jake) paralysis remains in the memory of American physicians who were practicing in 1929-1930 when epidemics in various parts of the country were observed. It was during prohibition and the victims had taken recourse in the imbibing of Jamaica ginger. No special harm resulted until an illegal batch contaminated with triorthocresyl-phosphate was distributed. This had a direct toxic affinity for peripheral nerves, particularly motor nerves. The condition was essentially a multiple neuritis. The small muscles of the hands and feet were predominantly affected, with atrophy, paralysis, and loss of reflexes. Wrist and foot drop were frequent. Hyperesthesia or hyperalgesia of the glove and sock distribution were frequent. The bladder and rectum were never involved.

Lead neuritis is now very rare. It is essentially a motor paralysis and commonly limited to the distribution of the radial nerve with symmetrical involvement of the interossei and the typical claw-hand contracture. The lower limb may be affected, with resulting foot drop. History of previous lead poisoning—colic and lead line—should be obtained.

Different forms of lead attack different parts of the nervous system. Metallic lead and the oxides produce the neuritis described above. Tetraethyl lead used in gasoline attacks the cerebral cortex. In children the lead in paint, with which they poison themselves by eating it off tags and furniture, almost invariably produces an encephalitis instead of a neuritis.

Oskar Vogt (Arch. Neurol. and Psychiat. 15: 262, 1926) has called these chemical affinities to the nervous system "pathoklia." Examples are named above: methyl alcohol for the optic nerve, the lead affinities, Jake and apiol paralysis for the peripheral motor nerves, carbon bisulfide for the sensory nerves of the hands and feet, trichlorethylene for the sensory branches of the trigeminal nerve. Motor nerves degenerate before sensory nerves. (The specific involvement of the lateral femoral cutaneous to cause *meralgia paresthetica* is an exception.)

Arsenical neuritis is a difficult diagnosis. In suspected lead neuritis the examination of the blood for stipple cells, and gums for lead line, can usually

be depended upon to establish the diagnosis. In alcoholic neuritis the existence of the etiologic factor is fairly clear. But with arsenic the origin of the poisoning can hardly ever be determined. In a series of cases reported by Hassin (J. Nerv. and Ment. Dis. 72: 628, 1930) the final proof was the chemical detection of arsenic sulfide in the cuttings from the hair and nails. In only one of this series apparently was the method of ingestion of the arsenic discovered, that being a patient who had a course of arsphenamine. Other means are from handling fly paper, rat poison, or artificial flowers; etching, fur processing, gardening, paper hanging, and taxidermy. It is a flaccid motor paralysis with trophic changes in skin (glossiness) and nails (white bands). The lower and upper extremities are affected about equally frequently. Sensory symptoms—anesthesia, pain over muscle and nerve trunks on pressure, and hyperesthesia—are present in about half the cases as prodromes.

3. **Myelomalacia** (softening, degeneration, necrosis, hemorrhage into section of the spinal cord) results in flaccid paralysis and loss of sensation from the level of the lesion down. It occurs from traumatic or pathologic (especially Pott's disease) fracture and dislocation of the vertebrae from hemorrhage into the cord, or thrombosis of a spinal artery from spinal cord tumors, and gumma, very rarely from syringomyelia or syphilis of the meninges.

Traumatic or pathologic vertebral disease need not be considered in detail. (See Allen: Injuries of the Spinal Cord, J. A. M. A. 50: 941, 1908.)

Vascular injury, with softening of the cord from ischemia following thrombosis or hemorrhage directly into the cord (nontraumatic), is rare. Hunt and Cornwall (Flaccid Paraplegia, J. A. M. A. 85: 186, 1925) report two cases due to thrombosis of the ventral spinal arteries in the lower cord, one originating from a thrombus in the abdominal aorta. King records a syphilitic thrombosis of a major spinal artery, resulting in flaccid paralysis (reference below).

Spinal cord tumor (see p. 597 and p. 598) produces classically sensory symptoms first and spastic paralysis, but two of Dandy's 33 patients had flaccid paralysis. (Ann. Surg. 81: 223, 1925.)

Syringomyelia also has predominantly sensory changes. The motor symptoms may be of any kind, depending on the place, extent, and direction of the glial growth. Flaccid paraplegia is a very rare form.

Syphilis of the cord, if it produces a paraplegia, usually produces a spastic paraplegia (Erb's syphilitic spinal paraplegia) or, of course, the ataxia of tabes. Flaccid paralysis is, however, not impossible. King (Syphilis of the Spinal Cord, Am. J. Syph. 26: 336, 1942) details cases of meningomyelitis and gumma with flaccid paralysis. *Amyotrophic meningomyelitis luetica* is a muscular atrophy, usually of the upper limbs.

In pre-Wassermann days all muscular dystrophies and atrophies were considered to be of syphilitic origin, the suggestion probably first being made by Graves in his *Clinical Lectures* (1795). This amyotrophic meningomyelitis is the only form still left in that category. The pathology is a leptomeningitis, usually throughout the whole length of the cord and medulla, although presumably (I say presumably because I can point to no specific case coming

under my observation) it may be localized; (2) a chronic ependymitis, (3) considerable and intensive degeneration of the anterior white matter in the cord, especially in Clarke's column in the cervical region, some degeneration of the central white, especially in the cervical region, the columns of Burdoh being least affected, (4) arteritis of the small vessels in the cord, and (5) an intense glial reaction toward both surfaces of the brain stem. The clinical features are atonic wasting of the muscles, usually beginning on and usually being confined to the arms (60 per cent in the small muscles of the hand) but rarely in the shoulder muscle (22 per cent) or legs (10 per cent in the peronei or anterior tibial muscles). The first complaints are weakness and dull pain. The reflexes progressively decrease. Sensation is not usually impaired. Twenty-eight per cent of cases have an Argyll Robertson pupil. The sphincters are seldom affected; if at all, there is slight urinary incontinence. The whole clinical picture greatly resembles Charcot-Marie-Tooth type of muscular atrophy. In two cases of this condition Marie reported Argyll Robertson pupils. Martin says syphilis is the commonest cause of atonic muscular atrophy. (Martin: Amyotrophic Meningomyelitis: Spinal Progressive Muscular Atrophy of Syphilitic Origin, Brain 48: 11, 1925.)

Most hysterical paralyses are flaccid in character. The characteristics of hysterical paralysis will be taken up in a special section on hysteria.

Flaccid hemiplegia nearly always occurs as part of the thalamic syndrome (q.v.) with occlusion of the posterior cerebral artery.

Spastic paralysis is due to disease of the upper motor neuron—in the brain the cells of the motor cortex or their pathways in the internal capsule, or the motor columns (usually the lateral) of the spinal cord. Spasticity is not entirely easy to explain. The following explanation by Dr. Stanley Cobb, while admittedly oversimplified, is helpful:

"The muscle is innervated only by the peripheral nerves, the motor fibers of which all arise from the anterior horn cells of the spinal cord. Any motor impulse, therefore, that reaches the muscle must travel along this path, and since the whole muscle acts as a unit in contracting, it may be taken for granted that the simultaneous impulses coming down each of the many nerve-fibers of the peripheral nerve are similar one to another. But there are many impulses that play on the anterior horn cell and affect the impulse that goes to the muscle, so the motor nerve-fiber is not only a final path for motor impulses, but it is the final *common* path down which all motor impulses must travel to reach the muscle, no matter what their source.

"With this conception of a *final common path* for the motor impulses clearly in mind, let us sketch the various sources of motor energy which play on the anterior horn cell. In the first place, impulses received in the peripheral sense organs reflexly affect muscle tone through short reflex arcs across the spinal cord, without bringing into play any of the brain centers at all. This simple reflex arc, though crude in its function, is all important, for if it is cut as in section of the posterior roots, no reflex muscle tone remains, and the higher centers, acting, as it were, blindly from above, have but a toneless ataxic muscle to play upon.

"The second great source of motor innervation is from the motor cortex via the corticospinal path, and with a lesion in this tract at a level higher

than the striatum we impair or destroy the power of isolated voluntary movements. We say 'isolated movement' because in injury to the corticospinal tract alone it is these high specialized, single and purposeful movements that are lost, not the gross associated movements of locomotion and bodily station.

"When the influences from the striatum as well as the cortex are removed, the uncomplicated impulses from the red nucleus and vestibular nuclei play on the anterior horn cell, and give the phenomena of decerebrate rigidity. As described above, physiologic experiments have shown the effects of the red nuclei, and then the vestibular nuclei. This leaves the isolated spinal cord acting as a reflex center, and explains the great loss of muscle tone seen after cord transection, as well as the possibility of quite extensive and complicated reflex action.

"In recapitulation, then, we can say that fundamentally the afferent impulses pouring into the central nervous system set up in the muscles that slight constant contraction we call *tonus*. Some of these impulses cross directly to the anterior horn cells via the simple spinal reflex arc, while others travel up to the brain and give rise to the energy which emanates from the great tonus centers in the nuclei of the striatum, in the red nucleus, and in the vestibular nuclei. On this whole mechanism the cerebellum has a great co-ordinating influence, and also an important though not well understood, tonic function. Lastly, the motor cortex of the cerebrum controls all these lower mechanisms through its power of initiating the isolated voluntary movements, which take temporary precedence over all other forms of motor activity, but are usually superimposed on these tonic postural reflexes, and do not truly inhibit them." (M. Clin. North America 4: 417, 1920.)

Clinically, spasticity falls into a few syndromes.

Hemiplegia, the commonest of the syndromes, is due to degeneration of the motor pathways in the cerebrum, and results in a spastic paralysis of one side of the body.

On a clinical classification most cases fall into these categories: (a) vascular cerebral accidents—rupture with hemorrhage, thrombosis or embolism, i.e., apoplexy; (b) syphilis; (c) cerebral tumor or abscess.

4. Hemiplegia.—Infantile hemiplegia is usually a diplegia and will be considered under *athetosis* below.

The lenticulostriate artery, a branch of the middle cerebral which traverses the lenticular nucleus and the internal capsule to terminate in the caudate nucleus, has been known since the time of Charcot as the artery of cerebral hemorrhage. For the ordinary form of hemiplegia with involvement of one arm and leg, without facial, tongue, palatal, or ocular palsies, the internal capsule is about the only place where a hemorrhage or thrombosis of one vessel can catch enough fibers to result in the syndrome. Hemorrhage into the cortex would have to be so widespread that it would almost inevitably create such pressure as to cause death. This statement should not be taken without qualification because exceptions occur (Nielsen and Friedman: Bull. Los Angeles Neurol. Soc. 7: 1, 1942, report hemiplegia from hemorrhage into the temporal isthmus), but it is a good working rule. If the lesion occurs on the left side of the brain in right-handed persons, aphasia is likely to accompany the paralysis.

The anterior cerebral artery supplies the anterior limit of the internal capsule and the upper part of the precentral gyrus. Accident to it causes contralateral hemiplegia accompanied by contralateral loss of sensibility of the cortical type and almost always, apraxia, usually of the pure motor type. No matter whether the right or left anterior cerebral is occluded in right-handed persons, the apraxia is on the left side. But when the hemiplegia is on the left side, the apraxia is likely to be marked. Aphasia occurs when lesion of the anterior cerebral artery is on the left side. This is probably a commoner cause of aphasia accompanying hemiplegia than lesion of the lentículo-striate artery. The middle cerebral artery, a branch of the carotid, has branches that terminate in the motor cortex. Thrombosis or embolism of the artery or, more often, one of its branches can result in partial hemiplegia or monoplegia. (See Alexander: *The Vascular Supply of the Strio-pallidum*, *A. Research Nerv. and Ment. Dis.*, Proc., 1940 21: 77, 1942.) Vascular accidents which occur in the arteries going to the pons and medulla result in syndromes involving various parts of the face, throat and eyes and also extremities, as described below (pontine and medulla syndromes). Occlusion of the posterior cerebral artery gives rise to the thalamic syndrome (q.v.), which sometimes is accompanied by a hemiplegia, but is usually flaccid.

Syphilis.—Arterial degeneration or hypertension is the cause of the hemiplegia of the middle aged and old; syphilis is the cause of the hemiplegia of the young. It is, however, essentially vascular with meningeal complications.

Intracranial tumor or abscess can cause hemiplegia, though not very frequently is the localization propitious for that result. They are discussed under separate sections below.

Irish (Tumor of the Brain With Sudden Onset of Symptoms, *Arch. Neurol. and Psychiat.* 23: 721, 1930) reviewed the 70 cases reported of sudden onset of symptoms in brain tumor. The suddenness is invariably due to hemorrhage into the tumor; 90 per cent of such tumors are spongio-blastomata. Most were located in the frontal region, the frontoparietal, temporal, or occipitoparietal. He records only one case in which a sharply defined hemiplegia occurred. Robinson (Hemiplegia, *J. Missouri M. A.* 27: 572, 1930) records one other such case.

Other causes are so rare as to be negligible. Multiple sclerosis may affect the internal capsule or cortex. Paresis may produce hemiplegia, but transiently. (Arteriosclerosis may also produce transient hemiplegias.)

Purpura hemorrhagica is a rare cause of apoplexy. Osler recorded two cases in his articles on Visceral Lesions of Purpura and Allied Conditions (*Brit. M. J.* 1: 517, 1914.)

It is hardly necessary to describe the typical apoplexy. The *ictus apoplecticus* (loss of consciousness) may be preceded by dizziness, headache, nausea, and clouding of vision. Immediate loss of consciousness without prodromes occurs in 50 per cent of instances. During the attack there is incontinence. Convulsion occurs in 13 per cent. The paralysis at first is flaccid, gradually giving away to spasticity. In about three-fourths of patients the face is not involved.

Differential diagnosis between thrombosis and hemorrhage can be made during life. Aring and Merritt (Arch. Int. Med. 56: 435, 1935) studied the case histories of 245 patients in whom autopsy had determined the condition, with a special view to determining signs and symptoms which differentiated thrombosis and hemorrhage. They found that the age with hemorrhage is slightly lower (average between 40 and 50) than with thrombosis. The onset with headache and vomiting is in favor of hemorrhage; so are convulsions. Immediate loss of consciousness occurred in 51 per cent of hemorrhage patients and in 35 per cent of those with thrombosis. Entrance to the hospital in coma was: hemorrhage, 68 per cent; thrombosis, 39 per cent. Progression of the symptoms after the initial status was more frequent in hemorrhage. Abnormalities of respiration—depth, rate, rhythm—were more frequent in hemorrhage. The blood pressure was somewhat higher (41 per cent had a systolic rate of 200 or over) in hemorrhage. Arteriosclerosis, as observed in peripheral and retinal vessels, was more frequent in hemorrhage. Conjugate deviation of the eyes, inequality of the pupils, and loss of light reflex was more frequent in hemorrhage. Stiffness of the neck was found in 55 per cent of cases with hemorrhage, and 7 per cent with thrombosis. Bilateral Babinski sign was found with about equal frequency in the two forms. Leucocytosis is often high in hemorrhage. Bloody spinal fluid was found in 74 per cent of hemorrhage cases, in 1 case of thrombosis, 2 cases of embolism.

Embolism can be suspected if there is a cause for it (endocarditis) and occurs at younger age levels. Fat embolism occurs after trauma, with fracture or injury to fatty tissue. There is a free interval of three to six days after the trauma. Pulmonary fat embolism usually accompanies the cerebral hemorrhage, indicated by dyspnea, cough, cyanosis, and hemoptysis.

Differential diagnosis in the stage of coma is difficult. A bloody spinal fluid is the surest sign. In a general city hospital practice there used frequently to be brought into my wards patients in coma who had both albumin and sugar in the urine, but who turned out to have apoplexy, so neither uremia nor diabetic coma can be assumed from such urinary findings. "The cerebral attacks in Stokes-Adams disease may resemble apoplexy. One stout patient, the subject of many attacks, had been bled so often that he had a label inside his coat: 'Do not bleed me in an attack.' " (Osler-Christian.)

Syphilis may be suspected in a patient with hemiplegia who is under forty years of age. The peak age incidence is thirty to forty. The lenticulostriate artery is affected. The paralysis is somewhat slower in onset than in hemorrhage. The patient seldom loses consciousness. There is, as a rule, rather rapid recovery even without treatment.

Spastic Paraplegia of the Legs.—The commonest causes are pernicious (Addisonian) anemia and multiple sclerosis. There are probably not now as many paraplegias due to pernicious anemia as before the liver treatment: I do not see as many, but I find no statistics on the subject. If my assumption is correct, multiple sclerosis is the commonest cause. Amyotrophic lateral sclerosis, syringomyelia, and Erb's syphilitic spinal paralysis are the rarer causes.

Spastic paraplegia occurs in 80 per cent of cases of multiple sclerosis. Depending on when the plaques form, there may be also spastic paralysis of one or both arms.

Amyotrophic lateral sclerosis is a definite system disease consisting of degeneration of the lateral tracts in the cord, of the anterior white cells of the cord, and the bulbar nuclei. All of these do not come at once, but in sequence, depending on which set of lesions develop first—atrophy of the hand muscles, spastic paraplegia, and swallowing and speech difficulties.

Spastic paralysis occurs in *syringomyelia*, depending, as in the case of multiple sclerosis, on the location and extent of the gliosis.

Erb's spinal syphilitic paralysis is in reality a tabes of the lateral columns. It makes its appearance about ten years after the initial infection. It begins with increasing fatigability and stiffness of the legs, gradually developing into a completely spastic gait. Sensory changes rarely present themselves. There is often difficulty in starting the stream of urine.

The Brown-Sequard Syndrome, due to hemisection of the cord, shows spastic paralysis of the limb below and on the same side as the lesion, and loss of pain and temperature sense and blunting of touch sense in the opposite limb.

Diplegia.—Spastic.

Cerebral Birth Palsy—Little's Disease.—The pathology is sclerosis and atrophy of the cortex on both sides. The cause is unknown. It is not intracranial hemorrhage due to injury during birth as was first erroneously suggested by McNutt in 1855, a concept that has permeated popular medical thought ever since.

Spastic paraplegia of the legs is the commonest form. Involvement of one or both arms is, however, not at all uncommon. Athetosis is the rule. Convulsions and mental deficiency are regular signs.

A peculiarity of the condition is that it is more likely to affect a first-born child than later ones. Prematurity is frequent in the victims. The condition may be recognized at birth, more often when crawling or walking is begun, or when finer movements have to be made. The symptoms may seem to develop suddenly when such fine movements are begun, leading to the assignment by the mother of a fall or head injury as the cause.

Hepatolenticular Degeneration—Wilson's Disease.—S. A. Kinnear Wilson (Brain 34: 20, 1912) described a syndrome as follows:

"Progressive lenticular degeneration is a disease of the motor nervous system, occurring in young people and very often familial. It is progressive and fatal; acute cases may last only a few months: one chronic case has continued seven years.

"It is characterized by a definite symptom-complex whose chief features are: generalized tremor, dysarthria, and dysphagia, a muscular rigidity and hypertonicity, emaciation, spasmodic contractures, emotionalism.

"In pure cases the affection constitutes an extrapyramidal motor disease, for the reflexes are normal from the point of view of the function of the pyramidal tracts.

"Although cirrhosis of the liver is constantly found in this affection, and is an essential feature of it, there are no signs of liver disease during life."

The age incidence is adolescence and youth—ten to twenty-six years are the recorded limits of onset, average fifteen years.

Males and females are equally affected.

Familial or hereditary incidence is recorded in three-fourths of the cases. Two reports show three children in the same family affected.

The liver shows a hob-nailed type of cirrhosis. Sometimes, but not always, it is palpable. There is never jaundice, but a greenish brown pigmentation of the cornea. The spleen has been reported enlarged.

The lenticular nucleus is the seat of marked cellular degeneration, with complete disappearance of cells in whole areas and a marked degree of gliosis.

Wassermann reactions have invariably been negative.

Tremor is an outstanding symptom, usually the first to appear, usually in the hands and arms. In advanced stages it involves head, trunk, and limbs.

Spasticity appears in the muscles of the face, arms, hands, legs, and toes. There is no Babinski sign. Contractures are common. The face, particularly, assumes a spasticity and becomes a sea of grimaces and foolish expressions. Speech and swallowing are affected by the hypertonicity.

5. *Ataxia*.—*Ataxic paralysis* is not really so much a paralysis as a failure of muscular coördination due to disturbed sensory impulses.

Tabes dorsalis luetica (locomotor ataxia) is one of the most frequent organic diseases of the nervous system. The pathology, as seen in the later stages of the disease, is a selective degeneration of the posterior columns of the spinal cord—the columns of Goll and Burdach, which are sensory carrying proprioceptive impulses from the tendons, joint surfaces, muscles, and bones. The degeneration is usually most marked in the dorsal cord, but may be in any part, leading to slight variations in the classical syndrome. Exactly why the posterior columns degenerate, or, in other words, where the origin of the degeneration is, has not been satisfactorily explained, although the usual and obvious answer—that the primary change is degeneration of the spinal root ganglia—is quite satisfactory. Changes can be seen in the spinal root ganglia quite early.

Other nerve disturbances affecting the oculomotor and sphincteric muscles, as well as the optic nerve, must be added independent of the posterior column degeneration.

Tabes dorsalis eventuates in about 1.1 per cent of all cases of syphilis. The primary and secondary manifestations may be very mild, are so mild, as a rule, that they go without treatment, which is often offered as an explanation of the development of the disease; but more satisfactory is the theory that there are types of syphilitic infection and one type has an affinity for the nervous system. I have records of three cases in which the early treatment was prompt, thorough, and competent.

The average period which elapses between the initial infection and the onset of *tabes* is given as fifteen years. However, in a few patients whom I have known intimately and been able to watch year by year, and in carefully analyzed histories, a continuous succession of premonitory symptoms can be made out leading up to the frank manifestations. These consist in bouts of

constipation and gastric disturbances (foreshadowing the gastric crises), attacks of neuralgia, eye troubles (frequent changing of spectacles), bladder disturbances, easy fatigability (one of my patients had to give up playing golf ten years before he began to be ataxic). Hindsight here was better with me than foresight, but I believe the occurrence of such symptoms, when they do not fit into the pattern of a neurotic personality, deserve consideration and investigation of the cerebrospinal fluid.

It used to be customary to divide the progress of the disease into three stages: preataxic, ataxic, and paralytic. And while this is rejected by many students as too arbitrary, it remains a fairly useful yardstick. The manifestations are so protean as to make classification difficult. Julius Grinker wrote: "He who masters tabes knows half of neurology."

Hugh Patrick made the useful epigram: "In the recognition of the disease, locomotor ataxia, the symptom, locomotor ataxia, is of very little importance. Incoordination is never the first symptom of tabes. *Never!*"

The patients, as a rule, come to a general practitioner first, or to any specialist rather than a neurologist, for pain—sciatica, intercostal neuralgia, rheumatism, headache, trifacial neuralgia; all manifestations of the lightning pains of tabes. They often go to the oculist because of gradual failure of vision or slight transient double vision. They go to the urologist for "kidney trouble," bladder trouble, frequent and urgent micturition (they probably have a large amount of residual urine), or for loss of sexual power. They go to the gastroenterologist for spells of vomiting or spells of nausea—the gastric crises. Or they go to a surgeon with a diagnosis of appendicitis, gall bladder disease, peptic ulcer, or cancer. The surgeons, I fear, are not quite so gullible as they used to be and have robbed the internist of one of his best jokes. We all used to be able to show triumphantly in a clinic of medical students at least one patient with a half-dozen laparotomy scars when the underlying pathology was tabes. (Fluoroscopy shows that during a gastric crisis there is a severe general contraction of the stomach, relieved by atropine.) Or they go to a laryngologist for pain in the larynx, hoarseness, dyspnea.

The most important groups of signs and/or symptoms in tabes dorsalis:

1. *Loss of knee jerks.* Argyll Robertson pupil. *Loss of vibratory sense over the shin bone to the tuning fork.* They go together in importance. Examine all these in every patient who comes to you. It takes but a moment and you make yourself safe. They may not always be present together, but if all are absolutely normal, your patient does not have tabes.

2. *Bladder Disturbances.*—Inability to start the stream of urine promptly or starting too promptly, which latter the patient dislikes to the extent of damp trousers. Residual urine is frequent.

3. *Lancinating Pains.*—They may be present for years preceding the ataxia.

4. *Analgesia of the legs*—loss or impairment of pain sense. A patient may have perfect response to touch, yet endure a needle thrust into the leg without pain.

5. *Ocular Paralysis or Paresis.*—The ocular paralyzes may be transient. Syphilis of the nervous system, specifically either tabes or paresis, is the cause

of an ocular palsy in nine cases out of ten. Ptosis comes on early and stays late. The old "snap-diagnosis" sign of tabes was wrinkling of the forehead, the effort of the patient to lift his eyelid.

6. *Failure of Vision*.—When optic atrophy occurs, there is, according to immemorial diagnostic belief, an antagonism between it and ataxia or any other symptoms—cases which Dejerine called "tabes arrested by blindness."

7. *Ataxia and Incoordination*.—The patient is insecure of himself when in the dark or standing with eyes shut. Among the automatic Romberg tests, the patient makes on himself, is staggering when he leans over the wash bowl to rinse off his face. A dramatic form of such discovery as it may occur to one in our profession is related by Dr. Conan Doyle in *Round the Red Lamp*:

"Men die of diseases which they have studied most. You couldn't have a clearer case than that of poor old Walker, of St. Christopher's. Walker was one of the best men in Europe on nervous disease. You must have read his little book on sclerosis of the posterior columns. I was his clinical assistant at the time Walker was lecturing on locomotor ataxia to a ward full of youngsters. He was explaining that one of the early signs of the complaint was that the patient could not put his heels together with his eyes shut without staggering. As he spoke he suited the action to the word. I don't suppose the boys noticed anything. I did and so did he, though he finished the lecture without a sign.

"When it was over he came into my room and lit a cigarette.

" 'Just run over my reflexes, Smith,' said he.

"There was hardly a trace of them left. I tapped away at his knee tendon and might as well have tried to get a jerk out of that sofa cushion.

" 'So,' he said, 'it was not intercostal neuralgia after all.'

"Then I knew he had had the lightning pains and the case was complete. He might have had another year of ignorance and peace if it had not been for the chance illustration in his lecture."

In Kipling's story, *Love o' Women*, is recounted another unusual moment of discovery. The principal character of the tale is called "Love-o'-Women" because he had a long record of seduction. In Kipling's day (the pre-Wassermann era) it was supposed that tabes dorsalis was caused by excessive sexual intercourse, an idea that happily has been abandoned—happily for my generation:

"He stopped an' struck the ground wid his right foot three or four times doubtful. 'Is that ground?' sez he. An' while I was thinkin' his mind was goin' up comes the dochter. Love-o'-Women starts to go on quick, an' lands me a kick on the knee while his legs was getting into marchin' order.

" 'Hold on there,' sez the dochter. 'Tention,' and Love-o'-Women stud so. 'Now shut your eyes,' sez the dochter. 'No, you must not hold by your comrade.'

" 'Tis all up,' sez Love-o'-Women. 'I'd fall, dochter, an' you know it.'

" 'Fall?' I sez. 'Fall at attention wid your eyes shut? F'what do you mane?'

" 'They call it Locomotus attacks us,' sez the dochter, 'bekaze it attacks us like a locomotive. An' it comes,' sez he, looking at me, 'from bein' called Love-o'-Women.' "

8. *Trunk Anesthesia*.—There is a diminution of tactile sense, not of pain sense, in the form of a band about the body at about the level of the nipples. When the anesthetic zone reaches as high as the second rib, it is likely to extend to the arms. The sign is present in about 80 per cent of well-marked cases; in incipient cases, about 40 per cent.

9. *Ulnar Anesthesia*—Biernacki's sign.—Pressing the ulnar nerve forcibly against the inner condyle of the humerus fails to elicit pain.

10. *Testicular analgesia*—Abadie's sign.—Absence of pain or disagreeable sensation when the testicle is forcibly squeezed.

11. *Hypotonus*.—Diminution of muscle tonus is always present in the more advanced cases. The patient can be doubled up like a jack-knife, causing no pain and requiring little force.

12. *Incoordination*.—The ataxic gait comes late; to recognize it requires no clinical acumen. Incoordination, however, can be demonstrated fairly early.

13. *Diminution of sexual power*.—Not always present.

14. *Anosmia*.—Due to destruction of the olfactory nerve.

15. *Impaired Muscle Sense*.—With his eyes closed the patient is unable to perceive slight passive movements made by the examiner. Sign may be elicited before ataxia appears.

16. *Persistence of Painful Impressions*.—A momentary painful pinprick or severe pinch is perceived as a prolonged stinging and burning.

17. *Crises*.—The gastric crises have already been mentioned. They tend to come on at regular intervals. One patient whom I studied over twenty years had a few days of preliminary nausea, about a week of severe vomiting, and then was free for a month. Cutting the spinothalamic tract reduces the vomiting, but this may be replaced by spells of nausea. Bladder and anal crises occur. Laryngeal crises, with sudden loss of the voice, are less common. One case is cited in which the onset of tabes was heralded in an actor by sudden loss of voice on the stage, one of the few historical events at which one would like to have been present. Harland (*The Larynx in Locomotor Ataxia*, J. A. M. A. 11: 924, 1907) states that the crises are due to spasmodic abductor paralysis.

In rare instances the sclerosis occurs very low down in the cord, so that the picture is that of a lesion of the *conus medullaris*—trophic ulcers of the rectum, incontinence, and ulceration on the feet. The patellar reflexes may be normal. (See Hassin and Carroll: J. A. M. A. 70: 755, 1918.)

Adie's pupil may be confused with the Argyll Robertson pupil. It is unilateral with the tonic pupil larger than the nontonic pupil. By the usual flashlight technique, reaction to light is absent, but if the patient is kept in a dark room an hour, the pupil dilates, and on coming into the light a sluggish contraction may appear. Adie names his syndrome "Tonic pupils and absent tendon reflexes." It is an heredo-degenerative disease located in the great autonomic centers of the diencephalon and their connections with the mesencephalon. It is irritative rather than paralytic like the Horner-Bernard syndrome. It may be produced by otherwise asymptomatic nervous syphilis. (See Lowenstein and Friedman: Arch. Ophth. 28: 1042, 1942.)

6. Pernicious Anemia—posterior column sclerosis of spinal cord.—It is probable that the nervous manifestations of pernicious anemia are diminishing in frequency and severity since the widespread use in early attacks of liver therapy. It was found soon after this therapy was introduced that if the anemia were treated early, cord changes were prevented. Waltmann in 1919 (Am. J. M. Sc. 157: 400, 1919) several years before liver therapy was discovered, found nervous lesions in 80 per cent. Young in 1932 (J. A. M. A. 99: 613, 1932) found in a series of 515 cases of pernicious anemia that 20 per cent had well-defined cord changes.

Pernicious anemia is associated with numerous forms of nerve degeneration. Addison observed: "*The mind occasionally wanders.*" Primary optic atrophy occurs in about 0.5 per cent of cases, multiple sclerosis, in about 3 per cent, but the most frequent lesion is a combined sclerosis of the posterior and lateral columns in the spinal cord. This begins with the formation of small plaques, with primary involvement usually in the posterior columns. The symptoms depend upon whether the posterior or lateral column sclerosis predominates. The usual picture is the somewhat paradoxical one of loss of vibratory sense, loss of knee jerks, and spastic gait.

About 10 per cent of patients come with symptoms which suggest involvement of the nervous system. The legs "feel like sticks," "as though in a cart," "the hands and feet feel padded."

Vibratory sense is diminished or absent in about 92 per cent of all cases of pernicious anemia. The patellar reflexes are increased in 39 per cent, diminished or absent in 36 per cent, unequal in 14 per cent. The Babinski sign is positive and increased in 26 per cent. The gait is ataxic in 28 per cent, spastic in 20 per cent, queer (spastico-ataxic, difficult to define) in 12 per cent, and normal in the rest. Urinary control is disturbed in 12 per cent of cases.

Friedreich's ataxia is a familial disease in which there is degeneration of the posterior columns, some cerebellar degeneration and terminally, degeneration of the lateral columns. The symptoms begin classically in the second decade with a slowly progressive ataxia of the lower extremities, gradually involving the trunk, arms, neck, and head. There is a marked hypotonus. Nystagmus is frequently present. The speech is slow, scanning, slurred, and monotonous. Cerebellar signs, including dysmetria, asynergia, dysdiadochokinesia, occur. Deformities and contractures are common—scoliosis, and the condition known as Friedreich's toe, pes varo-equinus with marked hyperextension of the big toe at the basal point, the end phalanx flexed.

Deep sensibility is decreased and the knee jerk is absent, but the Babinski sign is often present. The progress is slow—from twenty to forty years.

Cerebellar ataxia is gross incoordination like that of a drunken man. If the lesion is unilateral, the patient sways to the side of the lesion. It is like all ataxias, based not so much on lack of motor control, as on disturbance of sensory connections. Sherrington called the cerebellum the head organ of proprioception, but this is not entirely an accurate conception: removal of the cerebellum does not result in loss of sensation or modify decerebrate rigidity, an essentially proprioceptive reflex. The cerebellum receives optic, vestibular,

auditory impulses, as well as associating impulses from the vestibular nuclei, the olive red nucleus and thalami, so that coordinated movements involving balance, judgment of space and distance, sounds, position of the body in space, are all concentrated there. Besides the ataxia and disturbances of past pointing and diadochokinesia, there is hypotonia, and often nystagmus, intention tremor, speech difficulties. Sensation is not involved in cerebellar disease.

Cerebellar syndromes may be due to congenital agenesis or hypoplasia.

Hemorrhage, arteriosclerosis, thrombosis, and encephalitis are causative, but not as often as elsewhere in the central nervous system.

Cerebellopontine angle tumor is one of the commonest of all intracranial neoplasms.

Dyssynergia cerebellaris progressiva was described by Hunt (Brain 37: 247, 1914). It is an insidiously starting, slowly progressive sclerosis, particularly of the dentate nucleus. The age incidence is usually after fifty and a familial history is obtainable. The first symptom is a coarse tremor, localized and volitional. Later, hypotonia, dyssynergia, dysmetria, dysdiadochokinesia appear. The tremor becomes generalized, occurs at rest as a coarse wiggle of the head, neck, and extremities. A severely ataxic gait appears during the later stages.

Marie's hereditary cerebellar ataxia closely resembles Friedreich's ataxia, but differs from it in that the degeneration is in the cerebellum itself. Optic atrophy often occurs.

B. The Myopathies

The myopathies (atrophy, dystrophy, pseudohypertrophy of the muscles) constitute a group of peculiar and little understood conditions. Confusion is created in the student's mind by the innumerable eponyms which have been attached to the various conditions—Aran-Duchenne, Landouzy-Dejerine, Erb, etc. The most important feature of the group is that the practitioner should be able to recognize a case for what it is, so that he will be able to give accurate prognosis and not treat it for something else—such as syphilis. To this end five general features should be remembered. One should distinguish two general groups of these chronic muscle wasting diseases: one in which the muscles waste primarily and the other in which the atrophy is due to primary disease in the nervous system. Contrasting these groups note:

First—age on onset. The primary muscle wastings occur in children and adolescents, the neural group tends to begin in middle age.

Second—the distribution of the muscles involved is a clue to classification. In the primary muscle group the trunk and the proximal portion of the limbs are involved first. In the neural group the distal muscles of the extremities are involved first.

Third—fibrillary twitching is present only in the neural group.

Fourth—the familial incidence. The primary myopathies occur in several members of a family. The neural myopathies pick out one person in a family (even though there is an undoubted hereditary history).

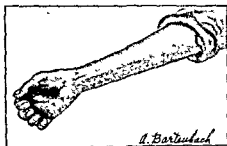
Fifth—spastic phenomena are absent in the primary myopathies; usually, but not always, present in the neural group—positive Babinski sign, etc., therefore point to the latter



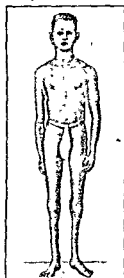
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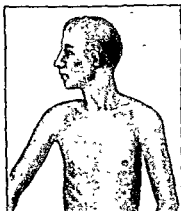
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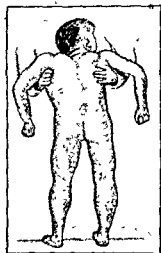
C



D



E



F

Fig. 70.—Nervous system—the myopathies. A, Landouzy-Dejerine type (fascioscapulo-humeral atrophy); B, Erb's juvenile type (progressive scapulo-humeral atrophy); C, Aran-Duchenne type (progressive spinal muscular atrophy); D, Charcot-Marie-Tooth (peroneal neural atrophy, "Stork legs"); E, Dystrophia myotonica of facial, neck, deltoid, and arm muscles; F, Pseudohypertrophic muscular dystrophy of Duchenne-Griesinger type. When a child of this type is lifted by the armpits, his head slides into the thorax.

Since no conclusions of importance can be drawn concerning the etiologic factors involved, a regional method of classification seems to me most convenient.

Facial Hemiatrophy.—Romberg's form is a rare affection in which the muscles, skin and bones and tongue on one side of the face become gradually atrophied. Female sex incidence predominates. The age of onset is fifteen to thirty. The skin is more affected than the muscles, with sometimes falling out of the hair on one side. For this reason most authors prefer not to classify it among the myopathies.

Facial hemihypertrophy (Friedreich) consists in the soft parts and bones of the face enlarging on one side only.

Myasthenia Gravis.—Erb, who first described it in 1878, called *myasthenia gravis* "bulbar paralysis without anatomical changes." This indicates sufficiently the characteristics of the disease, which is a wasting of the facial, ocular, lingual, and faucial muscles innervated by the bulbar nuclei. It begins with easy fatigability and goes on to partial paralysis. The patient notices first that in chewing the masseter muscles become weak and a period of rest is enforced, after which the muscles resume their power. Ocular weakness comes on at first in the evening, gradually appearing earlier and earlier in the day. The final stage consists of the *myasthenic facies*, a completely expressionless countenance with ptosis, often strabismus, poor speech, thin and high pitched, and poor swallowing movements. At no time does real complete paralysis occur, but atrophy of the affected muscles is an end result.

Sometimes the weakness is evident in hands or feet and this may be the method of onset, but as Dana says the diagnosis cannot be made unless the bulbar distribution is present. Sensation is unimpaired and fibrillary twitching absent. The muscles tire soon when subjected to rapidly repeated faradic stimuli and finally fail to respond (the *myasthenic reaction* of Jolly).

Remissions, complete or partial, are the rule. Pregnancy induced a remission in one of Grinker's cases. Such occurrences and other facts have given rise to the idea that the endocrine glands are in some way involved in the etiology, especially mentioned being the thymus. The age of onset is usually young, but any reported series of size has an age range from 15 to 70. Females somewhat predominate in sex incidence. Sudden death is frequent, the theory being that the heart muscle is involved. The course of the disease from observation of onset to death is from one to seventeen years. Often at the end of about fifteen years the phenomena become fixed, and death eventually is due to intercurrent disease.

About the etiology and pathology there is no definite knowledge. No lesions have been demonstrated in the central nervous system. The muscles themselves show few changes on histologic examination. Collections of lymphocytes called by Buzzard "*lymphorrhages*" are present, but their significance is unknown. There is probably a curare-like blocking of the nerve impulse at the myoneural plate junction. This accounts for the good results with prostigmine therapy. The association of thymus enlargement in about half the cases is unexplained.

In differential diagnosis, multiple sclerosis on account of the eye symptoms and remissions may give trouble. Hysteria, epidemic encephalitis, and the facial types of muscular dystrophy are other considerations. If its early manifestations be confined to the face, *dystrophia myotonica* (see below) is strikingly like it.

Facioscapulohumeral atrophy of Landouzy-Dejerine is perhaps the commonest of the myopathies. There is little difference between it and the Erb type except that the Landouzy-Dejerine type begins in early childhood and the facial muscles are prominently affected. It is rapidly progressive, there is atrophy and no hypertrophy of the muscles (except when as in rare cases it reaches the calves and they become hypertrophied), there are no fibrillary twitchings, the muscles of the face, neck, shoulder, girdle, and upper arm gradually waste. There is usually a wasting of the spinal muscles so that *lordosis* and a *peculiar carriage* are common. The patients may live for years unless the paralysis of respiration induces pneumonia or tuberculosis.

The **Juvenile scapulohumeral type of Erb** affects the scapular and humeral muscles sometimes, but seldom the face, tends to begin in youth or early adult life, is more slowly progressive than the Landouzy-Dejerine type. Pseudohypertrophy of the deltoids, triceps, and *infraspinatus* is common.

The **Aran-Duchenne type of progressive muscular atrophy** affects the hand and forearm muscles, producing in its final stage a claw hand. It begins with weakness, loss of ability to make fine movements, twitching, and tremor. It tends to be occupational in those who use the hands in their regular work, but the etiologic connection is not invariable. Spasticity occurs in the hands and sometimes in the legs.

It is of neural, not muscular origin. While its clinical course allows of a differentiation, it is pathologically so similar to amyotrophic lateral sclerosis that most neurologists consider them simply different forms of the same process. In Aran-Duchenne atrophy there may be no spasticity, but at autopsy lateral sclerosis of the cord is found which has been masked by the rapid progression of the disease. The course of Aran-Duchenne atrophy is much more rapidly fatal than amyotrophic lateral sclerosis.

The wasting of the hand muscles in *amyotrophic lateral sclerosis* may precede or follow the spastic paralysis of the lower limbs. The bulbar paralysis is usually terminal, but when bulbar paralysis occurs alone and causes death, there is usually pathologic evidence that the anterior horn cells in the cervical region and the lateral columns are affected. Amyotrophic lateral sclerosis affects males more than females in the proportion of about four to three. The age of onset is in middle life. There is a distinct hereditary tendency. The pathology shows degeneration of the lateral columns of the cord, which accounts for the spasticity, atrophy of anterior horn cells in the cord, which accounts for the muscular wasting of the hands, and degeneration of the bulbar nuclei.

Syringomyelia produces atrophy of the hand, usually accompanied by spastic contraction of a group of muscles—claw hand, preacher's hand (see p. 555).

Infantile Progressive Spinal Atrophy of Werdnig-Hoffmann.—This begins in infancy, affects the muscles of the trunk, pelvis, and shoulder girdle first, then rapidly the muscles of the hands and feet. There is final general muscular atrophy. Death occurs soon after onset. It is of extreme rarity. The pathology shows degeneration of the anterior horn cells and sometimes other cord changes. The hereditary and familial incidence is high.

Atrophy of Leyden-Moebius affects the pelvic girdle. This is the atrophic type of which the Duchenne-Griesinger type (see just below) is the hypertrophic type. It is not common. Wasting is present in the gluteal muscles, sometimes in the arms and legs.

Pseudohypertrophic muscular dystrophy of Duchenne-Griesinger is more nearly a well-defined clinical entity and more nearly regular in its clinical manifestations than others in the group. Pathologically there is no involvement of the nervous system, the changes occurring entirely in the muscles. The muscle fibers at first show hypertrophy, then atrophy with replacement of the fibers by fat and fibrous connective tissue. At this stage the muscle fibers show striation, splitting, and vacuole formation. On gross appearance, however, they always look hypertrophied.

The muscles involved are first those of the calf and thigh. In spite of the hypertrophic appearance they are weak and symptoms of weakness mark all the early symptomatology. The child at about the age of four shows unsteadiness of gait, and waddling. He has a compensatory lordosis and flaring scapulae. He falls down frequently and cannot get up unassisted. When he does get up unassisted, he exhibits the classical and peculiar phenomenon of climbing up himself, using his hands braced on his legs for this purpose. Later, other muscles are affected, especially the shoulder girdle, and when an attendant attempts to help him by grasping him under the armpits, he shows the phenomenon of slipping through; his neck and head telescope into his chest and his shoulders ride up to his ears.

The course of the disease is progressively downward, until the patient is bedridden, unable to perform any movements except perhaps with his hands. The course may be as long as forty years, though death usually supervenes about the age of eighteen on account of the liability to intercurrent infection.

Hypertrophica musculorum vera is a vaguely defined entity retained in textbooks by sheer inertia since Auerbach's description in Virchow's Archiv in 1871. There is hypertrophy of the muscles, but actual weakness, ready fatigability and dull pain and tenderness over the muscles. Reflexes and mentality are normal. The average age when the patient presents for diagnosis is twenty to thirty. Males predominate.

The Neural Peroneal Atrophy of Charcot-Marie-Tooth.—As stated above this disease may affect predominantly, primarily, and alone the muscles of the hands and arms, or of the feet and lower legs. Occasionally both upper and lower extremities are involved together in which happy event the victim is assured of a lifelong sinecure as a living skeleton in a side show.

The peroneal type is the usual one. The atrophy affects the muscles of the feet and lower legs entirely, stopping abruptly at the knee. There is often

a line of quite sharp demarcation on the skin at the knee where cyanosis of the lower limb begins. The thigh muscles, however, show a disuse atrophy. The appearance of the patient has been aptly named "stork legs." Mentality and sphincter control are not affected. There are some sensory symptoms—pains, cramps, loss of superficial, and deep sensibility.

The pathologic change of significance is degeneration of the ventral horn cells of the cord. The hereditary transmission of the disease is well established. Macklin and Bowman (J. A. M. A. 9: 613, Feb. 27, 1926) were able to work out one family history to five generations. Of 102 persons springing from affected stock, 21 were known to have had the disease. In the last generation studied, many were under the age of incidence, and in all generations a number had died in infancy, so the incidence is probably higher. The inheritance is not sex-linked; males and females are equally affected. The age of onset in this family ranged from twelve to forty, but in successive generations the onset definitely tends to occur at a younger age. The disease has no detrimental effect on the length of life; in this family the average age at death of those having peroneal atrophy was fifty-eight, of those not having it, fifty-five.

The distal type of muscular atrophy of Gowers was described by him in 1902 (Brit. M. J. 2: 1912) as wasting of the anterior tibial muscles and weak forearms and hands. He differentiated it from the Charcot-Marie-Tooth type because the peronei were not wasted, but few authorities have been willing to accept this as a separate entity.

Syringomyelia, when the gliosis affects the lumbar region, produces atrophy and weakness of the lower limbs of variable distribution. The accompanying dissociated anesthesia and, depending on the distribution of the lesion, either loss of deep reflexes or positive Babinski trophic lesions, occasional loss of sphincter control, and often clubfoot, serve to make the differential diagnosis.

Dystrophia Myotonica.—Atrophy of the muscles of the face, the sternomastoids, the pharynx, the forearm, the quadriceps and the dorsiflexors of the foot, combined with inability to relax the muscles after a purposeful contraction has been made (myotonia). This resembles Thomsen's disease except that here there is atrophy instead of the pseudohypertrophy of Thomsen's disease. Also the myotonia in this condition is limited to the hands while in Thomsen's disease all muscles participate. Waring, Ravin and Walker relate instances of how troublesome this symptom has been in some of their patients: a railroad brakeman almost lost his life because he could not let go the iron handle on a boxcar; a golf player could not relax his grip, frozen to his golf club, after a stroke; a physician who fell under suspicion because of his suggestively caressing hand clasp when shaking hands with his female patients.

The facial atrophy and the invariable sternomastoid atrophy give the patients a family resemblance. The speech and gait disturbances are slight. Foot drop and steppage gait occur. The reflexes are not disturbed except as might be expected. Babinski and Romberg signs are never present. There is never sphincter nor sensory involvement. Mental deterioration occurs in about one-third of cases. Cataracts occurred in 12 of 13 cases of Waring et al.

The age of onset is usually in the third or fourth decade. The hereditary nature is definite. It is extremely insidious and slow in its onset, so that cases go for years without recognition. Duration of life is not affected, all the symptoms finally becoming stationary. Waring, Ravin, and Walker believe it is far commoner than is generally supposed; 8 of their patients were discovered by purposeful investigation of the families of patients in whom they had recognized the disease; of the five of their patients presenting themselves at the hospital, not one had had his condition properly diagnosed. (See papers by Ravin and Waring: *Am. J. M. Sc.* 197: 593, May, 1939; and Waring, Ravin and Walker: *Arch. Int. Med.* 65: 763, April, 1940.)

Amyotonia Congenita, Myotonia Congenita, Oppenheim's Disease.—Muscular atrophy, atony, and hypoplasia with extreme weakness without paralysis manifested soon after birth and affecting nearly all muscles, but most regularly and prominently the legs, arms, trunk, and face in the order named. The mother during the pregnancy often reports that she feels no quickening, which indicates that the process is really prenatal in its onset. The muscles will contract when put in a favorable condition so there is no real paralysis, but weakness is such that the head is carried in a peculiar position. The posture, gait, and sitting position all show the adjustments imposed on the body. Hypotonus is extreme. Mentality is unimpaired. Nielsen reported the case of a boy whom he supposed to be an idiot from his expression and gait as he saw him on the street, but in reality he was at the head of his class in school. Sphincters and sensorium are not involved.

Pathology is not definite: the ventral horns are said to be poor in cells and the myelin of the ventral roots thinned. There is a familial occurrence. Similarity to the Werdnig-Hoffmann syndrome inclined many neurologists, including Hoffmann, to believe the two conditions identical. Not enough cases have been followed to be certain of the prognosis, but the tendency seems to be for the condition to become stationary at about the age of twelve, with no necessary threat to life involved. Hartenberg's report of a case at the age of fifty has been criticized.

C. Hyperactivity of the Muscles. The Dyskinesias

The motor cerebral cortex controls voluntary muscular movements. Below it are a number of basal ganglia, with which it has connections, and they in turn have connections with the anterior horn cells of the cord, with the optic thalamus and cerebellum. They are the corpus striatum, or globus pallidus, consisting of the caudate nucleus, the putamen of lenticular nucleus and the amygdalum—the red nucleus, the dentate nucleus in the cerebellum, Dieter's nucleus, and the reticular and tegmental nuclei within the brain stem. These are phylogenetically the oldest of the cerebral nuclei, and they control many subconscious and automatic movements: the righting reflex (ability to turn over when the body is on the back), extension and flexion reflexes, groping and grasping, muscle tonus. Their fibers make up the extrapyramidal system. Their connections with the thalamus and cerebellum are necessary for merging subconscious sensory impressions and coordination with their motor functions. In

the lower animals they take up more space than the cerebral cortex; the flight and balance of birds, the movements of fishes, the position reflexes of reptiles depend for their accuracy on these structures.

In a condition such as hemiplegia when the cortical cerebral cells are destroyed or whenever the pyramidal system is completely interrupted, this extrapyramidal system is freed from the cortical inhibition and produces increased tonicity of the muscles or spastic paralysis. (A distinction between spasticity and rigidity is made by Michelson: *New England J. Med.* 227: 112, July 16, 1942.) If the change of muscle tension involves both the flexor and extensor muscles it should be called "rigidity," but if the antigravity muscles are chiefly involved, the condition should be designated by the term "spasticity." Rigidity is found clinically in diseases of the extrapyramidal system; spasticity arises from lesions of the pyramidal system below the level of the cortex. Grinker (*Ztschr. f. d. ges. Neurol. u. Psychiat.* 135: 573, 1931) experimented with a human anencephalic monster that lived for several days after birth. The basal ganglia were exposed, with no cerebral, cortical, or subcortical tissue. On stimulating these masses with the Faradic current on one side, a complicated synergic flexion of the arm and leg on the opposite side occurred. It closely resembled athetosis. Localization of arm and leg movements was made. In another case of the same kind where some cerebral cortex was present, stimulation of these ganglia provoked no response.

The red nucleus is probably the center of the righting reflex. An intact animal has the ability to right itself to a normal posture from whatever position it has been made to assume. If the cerebral motor cortex be removed, it still retains this faculty, but if the connections to the red nucleus to the cord are interrupted, which is experimentally possible, it disappears. There are, however, other nuclei which probably share control of the righting reflexes.

The substantia nigra controls muscular functions difficult or too diffuse for definition. From the fact that it is extensively destroyed in paralysis agitans it has been assumed that this is the cause of the masklike expression of the face in that disease, and that the nigra presides over unconscious movements and changes of posture and bodily expression which are so integral a part of normal behavior that they are apparent only in their absence.

The functions of the corpora striata, as determined by animal experimentation, are not clearly defined. Large areas can be destroyed without producing any effect at all. Complete removal on one side produces a rigidity in the limbs of the opposite side, but this soon passes. When the motor and premotor areas of the cortex are more or less destroyed as well, destruction of the pallidum brings on a coarse tremor of the extremities. Electrical stimulation of the pallidum inhibits muscular movements. But in no animal experiment are there the clear-cut syndromes such as occur with the striatal lesions of natural disease which produce paralysis agitans and postencephalitic tremor. It was indeed the study of the epidemic of encephalitis of 1915-1925 with these sequelae that gave us most of our present knowledge of the functions of the basal ganglia.

Choreiform movements and athetosis are probably due to interruption of suppressor movements from the cortex in the globus pallidus.

The above is a deliberately oversimplified description of the functional pathology which results in the dyskinesias, hyperkinesia, chorea, athetosis, etc. For a fuller and modern presentation see Krieg's *Functional Neuroanatomy*, Blakiston, 1942, and Grinker's *Neurology*, C. C Thomas, 1943, ed. 3, Chap. X.

A. Tremors, Dyskinesias, Hyperkinesias.—

Paralysis Agitans, Parkinson's Disease.—

"The disease is of long duration: to connect, therefore, the symptoms which occur in its later stages with those which mark its commencement, requires a continuance of observation of the same case even for several years. These advantages the writer has had the opportunity of availing himself, . . . Involuntary tremulous motion, with a lessened muscular power, in parts not in action and even when supported; with a propensity to bend the trunk forwards and to pass from a walking to a running pace: the sense and intellects being uninjured. . . . So slight and nearly imperceptible are the first inroads of this malady, and so extremely slow is its progress, that it rarely happens that the patient can form any recollection of the precise period of its commencement. The first symptoms perceived are a slight sense of weakness with a proneness to trembling in some particular part; sometimes in the head, but most commonly in one of the hands and arms. . . . Hitherto the patient would perhaps seldom think of himself as the subject of disease. But as the disease proceeds, walking becomes a task which cannot be performed without considerable attention: writing can now be hardly at all accomplished. The patient seldom experiences a suspension of the agitation of his limbs. Commencing, for instance, in one arm, the wearisome agitation is borne until beyond sufferance, when suddenly changing the posture it is for a time stopped in that limb, to commence generally in less than a minute in one of the legs or in the arm of the opposite side. The propensity to lean forward becomes invincible. The sleep becomes much disturbed. The tremulous motion of the limbs occurs during sleep, and augments until they awaken the patient. The power to convey food to the mouth is at length so much impeded that he is obliged to consent to be fed by others. His words are now scarcely intelligible. When food is conveyed to the mouth, so much are the action of the muscles of the tongue, pharynx, etc., impaired that the food is with difficulty retained in the mouth until masticated and then as difficultly swallowed. The saliva fails of being directed to the back part of the fauces and hence is continually dribbling from the mouth. The chin is almost invariably bent down upon the sternum. The tremulous agitation becomes more vehement. It now seldom leaves him for a moment; but even when exhausted Nature seizes a small portion of sleep, the motion becomes so violent as not only to shake the bed hangings but even the floor and sashes of the room. And at last constant sleepiness, with slight delirium and other marks of extreme exhaustion, announce the wished for release." James Parkinson, *Essay on the Shaking Palsy*, 1817.

This graphic description leaves little for the modern nosologist to add. The immobility of the face—the Parkinsonian mask—is not noted by Parkinson. Charcot described some sensory alteration in the perception of temperature. Hanes (J. A. M. A. 121: 1152, April 3, 1943) described the whistle-smile reflex sign. "When the normal individual is requested to whistle he does so and then

smiles, probably a mimetic response to the absurdity of unmotivated whistling. The patient suffering from Parkinson's disease does not smile after whistling. For many years I have employed this simple test as an aid to rapid orientation and have found it very helpful and reliable." The reflexes are not changed. The pathology is primary degeneration of the cells of the globus pallidus and substantia nigra. Lacunae can be seen grossly on cut sections of the brain. The age of onset is from 50 to 60 in half the cases, from 60 to 70 in a third, from 40 to 50 in a seventh—this accounts for 97 per cent of cases, so onset below 40 and over 70 is rare. Male incidence predominates, but after 50 the female incidence rises. There is a distinct familial and hereditary tendency.

Postencephalitic Parkinsonism.—About 1916 the modern medical world was treated to the spectacle of a new form of epidemic infectious disease. While there had undoubtedly been epidemics before and there are vague references to some such malady in Germany in 1712, and in 1890 in parts of Southern Europe, it was for the medical profession in 1916 a new experience. Von Economo described it in 1917 under the name *lethargic encephalitis* (Wien. klin. Wchnschr. 30: 581, 1917), and the layman called it sleeping sickness. It was first observed in Austria and France, then in England in 1918, and was recognized in the United States toward the end of 1918. By that time it had become world wide, as indicated by the occurrence of a Japanese epidemic. It continued to be epidemic, reaching its height in 1924, when 5,000 cases were reported in the British Isles, 10,000 in France, 17,000 in Japan and 5,000 in the United States.* The St. Louis epidemic in 1933 produced over a thousand cases, and the recurrence in 1937 almost as many more. Since then only sporadic cases have been reported.

The symptoms and signs of onset are deep prolonged sleep, double vision, ptosis, inequality and irregularity of the pupils, nystagmus and paralysis of the third and sixth cranial nerves. Sensory disturbances are rare. In the myoclonic form there are widespread rhythmical muscular contractions. Many varieties are encountered—bulbar form, spinal form, neuritic form.

The cause is generally ascribed to a virus, although it has not been identified. The pathology is essentially a perivascular infiltration with subsequent possible destruction of nerve cells, particularly of the basal ganglia and substantia nigra.

Sequelae involving the nervous system are common, the most frequent being *postencephalitic Parkinsonism*. In the 1924 epidemic this occurred in one-third of the cases. The signs are not different from those of paralysis agitans: rigidity, tremor, dribbling, weakness, double vision (does not occur in paralysis agitans), masklike facies, flexed posture and gait, but the distinguishing feature in most instances is that they occur in young persons. In the severe forms the muscular agitation and rigidity outdo any case of paralysis agitans.

Arteriosclerotic Tremor.—The tremor of senility and presenility is probably due to cerebral arteriosclerosis with ischemia or necrosis of parts of the

*The figures for the United States are estimated from the 1,441 deaths reported, which is about the same as the number reported by Great Britain's. But undoubtedly many cases and deaths occurred from the disease, unrecognized or unreported.

globus pallidus and substantia nigra due to narrowing of the lumen and occlusion of the vessels. Its differentiation from true paralysis agitans is artificial. Rigidity and loss of facial expression are present in varying combinations and degrees. Many of the difficulties in gait of elderly people are semi-Parkinsonian. Mild dementia is a common accompaniment. The arteriosclerotic forms are perhaps not as progressive, and not as severe, they tend to reach a static stage, the tremor is more intentional, the pseudobulbar symptoms are not prominent and that is about all the difference between them and true paralysis agitans.

Toxic Causes.—*Manganese* and *carbon monoxide* poisoning frequently cause degeneration of the basal ganglia, resulting in the Parkinsonian syndrome. *Mercurialism*, always industrial, produces a vibratory tremor, affecting mainly the arms. The "fingers tremble by themselves." Weakness, gingivitis, salivation, etc., accompany this.

Multiple Sclerosis.—The classical triad of Chareot—intention tremor, nystagmus, and scanning or staccato speech—seldom occurs early in multiple sclerosis, but tends to signalize the advanced coalescence of symptoms. Nor are they pathognomonic; Wilson estimates that they occur in one-quarter of all cases.

"The tremor only manifests itself on the occasion of intentional movements of some extent: it ceases when the muscles are abandoned to complete repose." (Chareot.) It can be brought out by any purposive movement, such as finger-nose or heel-knee tests. It involves any part and often the head; it is really an intention tremor due to the neck muscles maintaining the posture of the head. It may be very evident or hardly perceptible. And sometimes after induction it does not pass off for some time, appearing then to be a "rest" tremor.

Exophthalmic Goiter.—The tremor is manifest by asking the patient to hold out the arms and spread the fingers. It can often be perceived more readily by palpation than by inspection. In severely toxic states, the muscles are very tremulous and the movements of the head and face may be choreiform.

Cerebellar tremor is usually the intention or action form.

Syndrome of Jakob.—Cortico-striato-spinal degeneration. Jakob (Ztschr. f. d. ges. Neurol. u. Psychiat. 56: 1920) called it "spastic pseudosclerosis, an encephalo-myelopathy with disseminated lesions." It is, however, too indefinite both pathologically and clinically to be an entity. The clinical features are onset in middle life, gradual development of weakness and stiffness, especially in the legs, with spastic or semispastic reflexes, rigidity, slowness of movement, tremors, hesitating speech and mental symptoms of anxiety and depression.

B. Muscular Spasm.—

Myotonia Congenita (*Thomsen's disease*) was described by Charles Bell in *The Nervous System*, but more graphically by Asmus Julius Thomsen (*Tonic Spasm of the Voluntary Muscles as a Result of an Hereditary Psychic Predis-*

position [Ataxia Muscularis] Arch. f. Psychiat. 6: 702-718, 1876), himself and several members of his family being victims of the disease, as follows:

"Certainly the most essential feature of the affection is a weakness in the influence of the will on the organ of voluntary motion, which manifests itself in all the muscles, sporadically in any one, sometimes in all of them, but chiefly in those of the extremities, especially the legs. These members are not so subject to the will as they should be, and at times give way entirely. . . . The phenomenon is frequently most strikingly apparent in the gait, which, when the tendency to these cramps is present, quite resembles that of a drunken man until the spasm relaxes. The principal exciting cause is a psychic one—the fear of the curse of making one's self ridiculous."

The musculature is well developed, so much so that Kinnear Wilson records two cases that developed in professional acrobats. The essential feature of the condition is inability to relax the muscles after a voluntary action. The patient will shake hands with you and then only after a long time and only with difficulty can he loosen the grip. He will stand up and start to walk and remain immobile as a statue trying to get the limbs to take up movement. The tendon reflexes may be increased or unaltered. Tapping over the muscle induces a slow, localized contraction. Faradic current evokes a twitch, which lasts an abnormally long time, cathodal and anodal closing contractions develop equally and relaxation tends to linger, galvanism causes undulating twitches from negative to positive pole. The muscles, in spite of their size, are really weak. Biopsy of the muscles shows nothing characteristic. There have been few autopsies. The potassium content of the muscles is low, as compared to a high potassium content in myasthenia. The prognosis for life is good, for improvement, poor.

Paramyoclonus Multiplex.—Friedreich (Virchow's arch. f. path. Anat. 86: 1881) described this disease which consists of abrupt clonic contractions of various skeletal muscles. His patient was a man of fifty, who had sudden spasmodic contractions first in one muscle and then in another. The muscles involved were the symmetrical groups of the arms and legs, the trunk being seldom involved. The contractions came on at the rate of 10 to 50 a minute and made the muscles stand out, but seldom moved the joints. They would often come so rapidly and severely as to result in painful tetanus. They continued all day long, were most severe as the patient lay in bed, and ceased on voluntary movement. Subsequent case reports have shown many variations in this clinical picture, both in severity of the spasm and in the number of muscles involved. Individual and nonsynergic muscles are likely to be involved, a cardinal point in diagnosis, differentiating it from ties. The face and ocular muscles are sometimes involved alone. The etiology and pathology are practically blank. Pierce Clark's patient had been a thumb-sucker, head-banger, and hair-puller, had enuresis and his sister was an epileptic (J. A. M. A. 58: 1912). The electric chorea of Henoch, and the electric chorea of Bergeron are probably the same thing.

Paramyotonia congenita of Eulenberg (Neurol. Centralbl. 5: 1886) involves the face, neck, throat, and, to a minor and infrequent extent, the limbs

in tonic spasm. Under the influence of cold, the patient becomes virtually speechless. Warmth gives relief. There is a familial tendency. It is difficult to see much distinction between this and the above.

Dystrophia myotonica consists of a spasm of the muscles on performing a voluntary act, such as shaking hands and not being able to let go, as in Thomsen's disease, but with a quite generalized atrophy of the muscles. It is not easy to classify, but I have described it in more detail under the atrophies.

Myotonia acquisita (Talma's disease) consists of a more or less continuous spasm of some muscles, most cases reported being in the calf muscles of the leg. It is not hereditary and appears to be brought on by trauma or infection. Male incidence predominates, the age onset being twenty to forty. Wilson doubts whether they are not cases of latent *myotonia congenita*. Recovery is usual and spontaneous. (See Nosik and Shannon: *Cleveland Clin. Quart.* 9: No. 4, Oct., 1943; and Moore: *Am. J. Syph.* 19: 409, July, 1935.)

Fibrillary chorea of Morvan applies to a continuous fibrillation of the calves and hamstrings.

Myokymia of Kuy and Schultze applies to a condition of cramps and fibrillation in the gastrocnemii, the peronei, rectus abdominus, deltoids, interossei and biceps.

Dubini's disease begins with lancinating and migratory pains and abrupt muscular twitchings. Nine per cent of Dubini's patients died, and since this report is dated 1846, it is probable he was describing an epidemic of encephalitis.

Traumatic acrodystonia follows injuries to the extremities, with callus formation which involves a nerve, and results in tonic spasm of a hand, finger, thumb, or feet. (See Bing and Haymaker: *Textbook of Nervous Diseases*, p. 143.)

Tetany consists of either continuous or intermittent spasms of muscles of the extremities. It is definitely related to calcium metabolism and disease or absence of the parathyroid glands. It occurs in rickets, or following pregnancy, following infection, diarrhea, gastric dilatation with vomiting, and may occur in epidemic form, in the spring, thus relating it to rickets. Removal of the thyroid which accidentally includes the parathyroids induces the most severe forms. Chemically it is caused by a lowering of blood calcium which disturbs the balance of sodium, potassium, magnesium and calcium, which balance preserves stability of the skeletal muscles.

In severe cases there are continuous tonic spasms of the arms and hands, the latter being in the obstetric position. The legs, if involved, are in extension, with plantar flexion of the feet and toes. The face is seldom involved, but may show trismus. Sensation is rarely disturbed, though there may be pain from the muscular contractions. The two classical and pathognomonic signs are those of Chvostek and Trousseau.

Chvostek's sign is spasm of the facial muscles when the area over the exit of the facial nerve in front of the external auditory canal is tapped with the forefinger.

Trousseau's sign is best elicited by putting a blood pressure cuff around the arm and inflating it. This produces a recurrence of the tetanic attack in the hand. Trousseau in his "*Clinique Medicale de l'Hôtel-Dieu de Paris*" 1862 wrote:

"I was led by chance to discover this influence of pressure. While performing a phlebotomy from the arm . . . on a woman who was suffering from (tetanic) contractures, I noticed that as soon as constriction was made with the tourniquet, there resulted an attack in the corresponding hand. I first thought that congestion produced by compressing the veins was the cause. However, in seeking to understand this phenomenon more clearly, I found that in other patients compression of the arteries acted in identically the same manner. Since then I have repeated the experiment many times, and inasmuch as it results in no inconvenience for the patients, since the attacks cease immediately when the procedure is stopped, I have often performed it before you. Now you will have noticed that the contracture showed itself not only on interfering with the arterial or venous circulation, but also on exerting pressure either over the median nerve in the arm or on the brachial plexus above the clavicle, and was immediately preceded by a sensation of tingling, which is the first symptom. These muscular spasms occur on compression of the femoral artery after placing a ligature about the thigh, or more simply still by firmly squeezing it between the two hands or by pressing over the sciatic nerve, although it is not so easy in the lower extremities.

"This phenomenon, which is interesting in itself, is not without practical application. It may contribute something to diagnosis for in no other convulsive affection can one produce an effect of this nature by similar means."

Tetanus.—The initial spasm consists in a stiffness in the muscles of the neck. The facial muscles show spasm early, producing the *risus sardonicus*, and the masseters produce the lockjaw. The entire trunk and back may be perfectly rigid, resulting in *opisthotonus*. The spasms last for varying periods, but even in the intervals the muscles are rigid. The slightest external stimulus—a noise, a light, a touch—is sufficient to set off an attack.

Rabies.—A premonitory stage is described when the patient is depressed and apprehensive. It passes into the stage of excitement or muscular spasm, which particularly affects the muscles of the glottis, accompanied by intense sense of dyspnea. Later the convulsions become generalized. The final is the paralytic stage.

Torticollis may be spasmodic or continuous. It is a great mystery, not associated with any pathology in muscle, bone, or nerves of the neck.

Occupational Spasms.—The best known is writer's cramp. The fingers develop painful contractions, so that only a few hesitant and illegible words can be written before the pen falls from the hands. Telegraphers, watchmakers, milkers, in fact any one doing fine or continuous work with the hands are subject to similar cramps. The basis is a neurosis.

Tics are in a vast majority of cases confined to the face or upper extremities. Winking, grimacing, shoulder shrugging are forms familiar to everyone. Most cases are a form of compulsion neurosis, but a few, such as postencephalitic, are organic.

C. Chorea

Sydenham's chorea has never been better described than by Sydenham himself (On St. Vitus Dance, from *Processus Integri*, Chapter XVI).

"This is a kind of convulsion, which attacks boys and girls from the tenth year to the time of puberty. It first shows itself by limping or unsteadiness in one of the legs, which the patient drags. The hand cannot be steady for a moment. It passes from one position to another by a convulsive movement, however much the patient may strive to the contrary. Before he can raise a cup to his lips, he makes as many gesticulations as a mountebank; since he does not move it in a straight line, but has his hand drawn aside by spasms, until by some good fortune he brings it at last to his mouth. He then gulps it off at once, so suddenly and so greedily as to look as if he were trying to amuse the lookers-on."

The relationship of chorea to rheumatic fever may be realized in the statistics of Jones and Bland, who found evidence of rheumatism in 74 per cent and of endocarditis in 54 per cent of their series of chorea cases.

Huntington's chorea was described by George Huntington in 1872. His father and grandfather before him had observed the muscular movements, antics and grimaces of certain groups of people on Long Island.

Huntington wrote:

"The hereditary chorea as I shall call it is confined to certain and fortunately a few families and has been transmitted to them, an heirloom from generations away back in the dim past. . . . It is attended generally by all the symptoms of common chorea, only in an exaggerated degree, hardly ever manifesting itself until adult or middle life, and then coming on gradually but surely, increasing by degrees, and occupying years in its development, until the hapless sufferer is but a quivering wreck of his former self. It is more common among men than among women. There are three marked peculiarities in this disease: 1. Its hereditary nature. 2. A tendency to insanity and suicide. 3. Its manifesting itself as a grave disease only in adult life."

The victims Huntington studied were all related and could trace their ancestry back to a group of three immigrant families who landed in Boston in 1630, all having come from the village of Bures, Suffolk. Many of them had been executed as witches during the period of that public hysteria. The choreiform movements are grimacing, lurching, gesticulating, and ataxic gait, which in the terminal stages prevents walking at all. It is considered at present that the principal pathologic changes are in the striate bodies which become greatly shrunken. There is also almost invariable involvement of the cerebral cortex. (See Huntington: On Chorea, *Med. and Surg. Reporter* 26: 317, 1872, and Vessie: On the Transmission of Huntington's Chorea for 300 years—the Bures Family Group, *J. Nerv. and Ment. Dis.* 76: 553, 1932.)

D. Athetosis means literally without fixed position. The member affected, usually hand and arm, is the seat of continuous slow writhing movements. Any variety of distribution is possible—the face and neck and trunk alone may be affected, or one hand and arm, or both, or the feet and legs. The movements

cease in sleep. The commonest cause is birth injury, although the exact nature of this is somewhat in dispute, as in the case of cerebral diplegia. Putman found a definite history of birth injury in 18 of a series of 35 cases. Post-encephalitic athetosis occurs. Double or bilateral congenital athetosis is described as a separate entity.

E. *Torsion spasm, or dystonia muscularis deformans* is a syndrome without distinct pathologic individuality although the first autopsy obtained showed lenticular degeneration and cirrhotic liver (Thomella: *Neurol. Centralbl.* 41: 1918). It occurs mostly among those between the ages of eight and fifteen, and mostly in the Jewish race. The cardinal features are a spasmodic writhing and torsion of the spine and pelvis.

F. Convulsions.—

Epilepsy.—Neurologists speak of "the epilepsies" and distinguish motor, sensory, psychic and visceral forms. But aside from Jacksonian epilepsy and the uncinate group of fits, there is little difficulty in the diagnosis of the grand mal of epilepsy. Petit mal may be invoked as a category to include the fugues and other forms of psychic epilepsy and will come under the terms of the definition that Hughlings Jackson himself gave to epilepsy "an occasional, nonvolitional, paroxysmal discharge of the nerve centers," to which Foster Kennedy adds "accompanied with some alteration of consciousness."

The incidence of epilepsy is high. It has been placed at two per thousand of the population, but in World War I it was found that 5 out of a thousand of draftees were epileptic. The number in institutions is, of course, only a very small proportion of the complete epileptic population. This accounts for the fact that nearly every attack of grand mal I have ever witnessed from beginning to end has been quite accidental, while I was in a restaurant, theater, and once in a medical meeting where a paper on epilepsy was being read. Seventeen per cent of all epileptics have their first convulsion before the age of five; 14 per cent between six and ten; 28 per cent between eleven and fifteen; 18 per cent between sixteen and twenty; 7 per cent between twenty-one and twenty-five, and only 2 per cent over the age of fifty-five.

There is a homely bit of doggerel, containing Anglo-Saxon words for which apology is hereby offered, which serves as a memory helper for the succession of the phenomena of the grand mal:

*"The aura, the cry, the convulsion, the fit.
The tonus, the clonus, the piss and the shit."*

The aura, or premonitory warning, or local signature of the attack has been estimated to occur in 50 per cent of patients. The aura may be sensory, motor, visceral, or psychic. Sensory aura are sensations of numbness, tingling, pricking, pins and needles, visual images (flashes, sparks, stars, colors, rainbows, hallucinations as of a little old man in a black overcoat, with a knapsack on his back, or of the nine of diamonds) auditory (hissing, sizzling noises, explosions, bells, whistles, a voice singing always the same thing, "hearing everything that has been said to me all my life"), olfactory and

gustatory. Motor aura are cramps, twitchings, restlessness, immobility. Visceral aura are epigastric sinking feeling, hunger, dyspnea, feeling of being strangled, cephalic ("as if my brain were being stirred about"). The psychic aura include the sense of "déjà vu," of having lived through this minute before, of remembering a former existence, or of complete strangeness, or of seeing into the center of things, of understanding the reason for the universe (which unfortunately they can never remember afterwards). They are related to the fugues, or dreamy states, but during a waking period, described by Janet as one of the major symptoms of hysteria.

These psychic aura are the most interesting part of the whole phenomenon to most of us, and occur quite independently of actual epileptic attacks to many persons. Rosetti described one poetically:

"I have been here before
But when or how I cannot tell
I know the grass beyond the door
The keen sweet smell
The sighing sound, the lights around the shore.
"You have been mine before
How long ago I may not know
But just when at that swallow's soar
Your neck turned up
Some veil did fall, I knew it all of yore."

Kipling's *Finest Story in the World* is a fictional account of an aura, or a fugue, in which a London clerk reveals in trances to the author his former life as a Viking. The theory of the transmigration of souls must have been revealed to Pythagoras from his experience with such fugues.

The *cry* is due to the spasmodic contraction of the muscles of respiration, most authors say expiration, Kinnear Wilson says inspiration. Russell Reynolds compared it to the "distracted cry of the peacock."

The *tonic* and *clonic* convulsive phenomena require no description.

Consciousness is nearly always lost, that being the differential point usually made between the *grand* and *petit mal*.

Postepileptic state besides the relaxation of the sphincters includes intense cyanosis which is due to breath holding and often seems to the spectator to be going to last to the point of exitus, vomiting, and either a period of complete unconsciousness, sleep, or stupid dazed state. *Status epilepticus* consists of a series of convulsions following one another, with no intervals of clear consciousness in between. A patient of record had 488 major fits in twenty-four hours. Death is common in such states.

Postepileptic automatism is a state which may last for hours or days, during which the patient is completely amnesic and disoriented and may be extremely dangerous; many cruel acts of violence, including murders, have been committed during such periods.

Mental deterioration of the epileptic is common, and in fact deficiency is associated with epilepsy in about 86 per cent of patients in asylums, and a

considerable mental limitation occurs in about 35 per cent of those who pursue careers outside of institutions. On the other hand, mental brilliance is often an accompaniment: tradition states that Julius Caesar, Napoleon, Richelieu, Swedenborg and Mahomet were epileptics.

The *petit mal* is difficult to delineate. The chief difference between it and *grand mal* is the absence of convulsive phenomena in *petit mal*. Consciousness is suspended or impaired rather than lost. The forms of *petit mal* include: (1) *Absence momentairee*, a sudden and very transitory suspension of the higher psychic functions; the patient ceases all activities, and remains staring into space. He may make a series of purposeless movements or grunts, or utter a string of senseless words; (2) *Vertigo* in which the patient sways or falls; he may have slight incontinence, usually turns pale; the falling sickness of Caesar; (3) *Epileptic syncope* is much the same, but may be accompanied by swaying movements.

The *pathology of epilepsy* is very much a blank. Histologic and chemical researches have resulted in little enlightenment. Myerson, Halloran and Hirsch (Arch. Neurol. and Psychiat. 17: 807, 1927) developed the technique of inserting a needle into the lumen of the internal jugular vein with safety. Blood withdrawn by this means has been studied with a view to throwing some light on the metabolism of the brain. The respiratory quotient of the brain is unity. Its activities are closely dependent on glucose. In *petit mal* patients, the blood from the brain showed a lower concentration of carbon dioxide than normal, the respiratory quotient of the brain is below unity, and the brain burns less glucose per unit of oxygen than it should. It has been possible to improve this therapeutically with consequent clinical improvement, although the methods are not simple enough as yet for general application.

Very important light has been thrown on the nature of epilepsy and other conditions by the application of the method first proposed by Berger (Arch. f. Psychiat. 87: 529, 1929). This is the record of electric pulsations of the cortex of the brain, transmitted through the skull, called *electro-encephalography*. Normally the brain produces regular, rhythmic electric waves which can be recorded. The normal waves are: (1) alpha, or 10 per second rhythm, equally spaced and of equal height, recorded when the subject is lying passive with closed eyes: these waves cease when the eyes are open and are replaced by (2) beta, a 25 per second rhythm; these are found over the occipital region; (3) gamma waves are 50 to the second found over the frontoparietal area; (4) hypothalamic waves from a special lead are 4 to the second; (5) delta waves are found in deepest sleep and are coarse, large and slow. Epilepsy is considered a cerebral dysrhythmia. The electro-encephalogram records sharp, irregular, spiked waves at the rate of about 3 per second during a seizure, the record returning to normal waves shortly after. The seizure can often be predicted by the appearance of groups of abnormal rhythms. Individuals have characteristic brain-wave patterns, and those of identical twins are identical; so it is an hereditary mark. It is possible by studying the individuals of the family of an epileptic to pick out abnormal rhythms in 52 per cent of instances.

Jacksonian Epilepsy.—Convulsions of an epileptic nature may occur in strictly localized muscle groups. These were described by Hughlings Jackson and his name remains as an eponym. The cause is, in most instances, an organic lesion in the motor cortex, but there are instances on record where focal convulsions occurred without any such definite pathology. Consciousness is seldom lost in a Jacksonian attack. The aura is likely to be pain in the parts which subsequently will be the seat of spasm. Jackson noticed that the spasm affected parts that had the greatest number of voluntary uses—the fingers, hands, toes, feet.

Brain tumor leads the list of causes of Jacksonian attacks (48 per cent of Roland's series). Parker (Arch. Neurol. and Psychiat. 23: 1032, May, 1930) found that 21.6 per cent of his cases of brain tumor had major epileptic attacks; in about one-sixth of these, the attacks were the first and only symptom. Gotten (J. A. M. A. 96: 1118, April 4, 1931) found three brain tumors in a routine study of fifty-six patients labeled epilepsy. Sachs and Ludlow (J. Missouri M. A., April, 1936) report that 150 of their verified brain tumor patients had convulsions; 138 of these tumors were localized in the cerebrum and 12 in the cerebellum; none of their pituitary tumors produced convulsions. The tumors were most frequently of the encapsulated sort, astrocytomata, and thus favorable for surgical removal.

Brain abscess was found in two instances in Bennett's series of 200 patients with the presenting symptom of epilepsy. He found cerebrospinal syphilis in 3.5 per cent of this group (Am. J. M. Sc. 178: No. 5, Nov., 1929). I have records of several cases of vascular cerebral syphilis with thrombosis and complete occlusion resulting in an atrophy of the motor area of the cortex with repeated localized convulsions.

Eclampsia.—Convulsions due to eclampsia or to the kidney of pregnancy should seldom cause any diagnostic quandary. The important thing is for the clinician to predict and prevent them. This is done, of course, by regular blood pressure readings and urinalyses during the pregnancy. Whenever there is the slightest tendency to a progressive rise in blood pressure, additional and more frequent examinations, including the blood chemistry must be made. Rise in the diastolic pressure is especially significant.

Uremic convulsions are also predictable, although not much can be done about it. The onset of muscular twitching and irritability is a bad sign in a nephritic. When a patient is brought into a hospital ward following a convulsion and the physician has no previous history to guide him, the diagnosis is somewhat more difficult, but if the age is above 50, it lies between uremia and paresis, and the Wassermann and urinalysis should clear it up.

Meningitis, or rather the sequelae of meningitis, accounts for about one-fifth of all cases of frank Jacksonian epilepsy. Most of these are syphilitic.

Trauma was the etiologic factor in 8 per cent of Roland's series of focal epilepsy.

The uncinute group of fits is due to tumors in the temporal lobe involving the centers of taste and smell. The aura are sensations of taste and smell, sometimes pleasant, more often disagreeable and even nauseating. These sensations

may constitute the entire attack, at least at first, and later consciousness is lost and true convulsions are superimposed. Sensations of smell and taste followed by a dreamy state, without loss of consciousness or convulsion is another form. (Mills: J. A. M. A. 51: 879, Sept. 12, 1908.)

General paralysis of the insane, paresis, is often ushered in by a convulsion. A first convulsion in middle age should immediately arouse suspicion of paresis.

Cysticercus, the embryos of the pork tapeworm, may invade the brain and cause convulsions.

Hysterical convulsions are a common manifestation of the disease, but the hysteric fit does not have the orderly progression of the symptoms that characterizes epilepsy, and the differential diagnosis is not difficult.

The terminal stage of *hydrophobia* produces convulsions in rapid succession.

G. Muscular fibrillation and twitching occurs in any muscle as it is undergoing degeneration. For instance, in *progressive muscular atrophy*, or in the hands in *amyotrophic lateral sclerosis*. It has, so far as I know, no other significance.

H. Nystagmus is a series of rhythmic, biphasic movements of the eyes, the eyes in the first phase deviating from their position of rest or fixation and in the second phase returning to their original position. The motion is usually lateral, but may be up and down or rotary. Sudden blindness, for instance, detachment of the retina in *eclamptic edema* almost invariably produces nystagmus. Disturbance of the semicircular canals will produce it; it is one of the criteria in the Bárány test. It is one of the Chareot triad of signs of multiple sclerosis. Both *Freidreich's ataxia* and *Ménière's disease* produce nystagmus. It is an occupational disease with miners and train dispatchers.

II. DISEASES OF THE SENSORY SYSTEM

A. Neuralgias

1. Neuralgia of the Fifth Nerve. Trifacial Neuralgia. Tic Douloureux.—True *tic douloureux* is a definite entity. All neuralgias of the face are not tic. Sluder's neuralgia, postzoster neuralgia, geniculate ganglion neuralgia, those due to tumor involvement of the gasserian ganglion, and so-called minor facial neuralgia have fairly definite clinical features which are discussed below.

It is hardly debatable that true *tic douloureux* is due to disease or deterioration of the gasserian ganglion, which is for all intents a spinal root ganglion. No single cause for this is known. The disease almost never attacks anyone less than forty and usually fifty years of age, so it is a fair assumption that the arteriosclerotic changes found in the ganglion are to a considerable extent causative. Diabetes, syphilis, dental caries, and sinus disease are all mentioned as causes. In the case of diabetes, the well-known bad effect diabetes has on arteriosclerosis, as seen in angina and peripheral vascular disease, operates here and allows us to consider diabetes as a secondary factor. Dental caries and nasal infection are so common in people of the age to have tic that they are hardly to be taken very seriously; besides treatment directed

along this line has a record of 100 per cent failure. Syphilis as an explanation should be subjected to the most scrupulous criticism. It is said that malaria and influenza are particularly likely to affect the ophthalmic division, diabetes and syphilis the mandibular division, but that statement also demands the salt cellar.

The pain of *tic douloureux* comes in paroxysms, in cycles with periods of remission, is always confined to the area supplied by the fifth nerve, and except when bilateral does not cross the midline. Ophthalmic and maxillary forms are rarely bilateral, the mandibular is fairly commonly so. The attacks are brought on by cold, and by cold winds or drafts. There are trigger points on the face, which when touched precipitate an attack. Drinking a glass of water or chewing may act as a trigger. The motor branch of the nerve is never affected. Lacrimation frequently accompanies attacks.

The pain is probably as excruciating as anything a human being is called upon to endure. It is described as knifelike, stabbing, burning, or like an electric shock. To see a valued patient or friend in an attack is almost unmanaging.

The diagnosis must be made on clinical history and the subjective account alone. The physical examination reveals no objective findings. The Valleix pressure points are of little help. For the ophthalmic branch the Valleix points are the supraorbital foramen, the nasal point near the inner canthus of the eye and over the eyelid at the point of exit of the lacrimal nerve; for the maxillary branch the inferior dental, molar, and dental point on the gum of the upper jaw; for the mandibular the mental, and dental point on the gum of the lower jaw.

Sphenopalatine Neuralgia. Sluder's Neuralgia. Lower Face Headache.—The sphenopalatine or Meckel's ganglion is a large sympathetic ganglion associated with the maxillary branch of the trigeminal nerve; it is deeply placed in the pterygopalatine fossa and supplies nerves to the nasal mucosa, the hard and soft palate, the orbit, external auditory canal, mastoid region, and skin of the temporal region. Sluder (see Sluder: *Headache and Eye Disorders of Nasal Origin*, The C. V. Mosby Co., 1918) described a syndrome in which this nerve is involved due to nasal infection and sinus disease as follows:

"Pain in the root of the nose, in and about the eye, in the upper jaw and teeth, extending backward under the zygoma to the ear, severest often at a point 5 cm. back of the mastoid, extending thence to the occiput, neck, shoulder blade, breast, and when severe to the arm, forearm, hand and fingers, with sometimes a sense of sore throat on the same side. Mild cases are described as a sense of tension in the face, and stiffness, or rheumatism, in the shoulder." It is usually a constant pain with exacerbations, but may come in paroxysms like *tic douloureux*. Diagnosis can be made on the basis of the distribution of the pain, the constant association with sinus disease, and the fact that cocaineization of the site of the ganglion relieves the pain.

Geniculate Ganglion Neuralgia.—The geniculate ganglion is the ganglion of the sensory part of the seventh nerve. It has connections with the otic and Meckel's ganglion, and its fibers supply the tympanum, a small area of skin

on the back of the ear and over the mastoid. Ramsey Hunt, a number of years ago, described herpetic eruption and neuralgia due to disease of this ganglion, (See Hunt: *J. Nerv. and Ment. Dis.* 34: 73, 1907; and Hunt: *The Sensory Field of the Seventh Nerve*, Brain 38: 418, 1915.) The herpetic form of this neuralgia shows eruption on the posterior field of the external ear and sometimes on the front of the external ear and down the neck. Facial palsy has accompanied it. Such cases should be easy to recognize, but "primary" neuralgia also occurs, with herpes; it is not always confined to the skin areas designated, but radiates so that large areas of the mastoid, temporal, occipital, and neck region are involved. The pain is very severe and is described as *deep and boring, as if it were in the bone, so much so that mastoidectomy has been performed.*

Brachial and cervicobronchial neuritis is a distinct clinical entity next in frequency among the definite neuralgias to facial and sciatic. In my experience it occurs in middle-aged individuals the subjects of a chronic disease, particularly diabetes.

Intercostal Neuralgia.—Intercostal neuralgia may occur as such, an idiopathic pain of one or more nerves induced by focal infection or diabetes, but the burden of proof lies on the physician to find an underlying cause—pleurisy in most instances, *herpes zoster before the eruption, spondylitis, the lancinating pains of tabes and diffuse proliferating leptomeningitis or arachnoiditis.* (See p. 91.) Only when these are eliminated may the diagnosis of ("idiopathic") intercostal neuralgia be allowed.

Spinal Cord Tumor.—Pain is the first symptom in over half of all spinal cord tumors. It may precede localizing signs by years—as many as five in a case of Putnam's, six months to a year in several of my own. When a level of anesthesia can be established, or paralysis, sphincter involvement or altered reflexes superimpose, the diagnosis is usually easy, but in the stage of pain alone the tumor is seldom suspected even by the most expert.

The nature of the pain is neuralgic, accompanied by paresthesia, tingling, burning, etc., and varying in intensity as any neuralgic pain does.

It is radicular, corresponding to the spinal cord level of a sensory segment or ganglion rather than to the distribution of a peripheral nerve.

The location may be anywhere—most often unilateral of an intercostal distribution, next most often imitating a sciatica, but varying, of course, with the vagaries of the location of the tumor itself and its relation to spinal structures, intradural or extradural.

Pathologically spinal cord tumors are classified as extradural and intradural and the intradural ones are subdivided into intramedullary and extramedullary. The extradural tumors may arise from any structure: dura (fibroma, fibrosarcoma, sarcoma), blood vessels (angioma), bone or cartilage (osteoma and chondroma), nerve tissue (neurofibroma), and fat (lipoma), and metastases. And, of course, we include clinically the inflammatory tumors—gumma and tubercle (which Schlesinger found to be the commonest of all spinal tumors). The intradural extramedullary tumors are fibroblastoma arising from the meninges and nerve root-sheaths, according to most clinics

the commonest of cord tumors; other extramedullary tumors are endotheliomata and psammomata. The intramedullary tumors are ependymomata, gliomata, and hemangioblastomata.

About half the spinal cord tumors are metastatic; of the primary tumors, about three-fourths are benign. Combined statistics from several clinics show that 28.7 per cent are extradural, 51 per cent are extramedullary, and 20.1 per cent are intramedullary.

When the tumors have begun to produce a transverse level of anesthesia and some degree of paraplegia, it is possible to localize it largely by determining the level of anesthesia. This requires great skill, patience, and experience, and, in fact, confirmation by re-examination two or three times by different observers, until an agreement has been reached, is advisable.

Laboratory procedures are of some help in confirming the diagnosis of spinal cord tumor. The decision to make a lumbar puncture requires some judgment. Relief of pressure may precipitate a hemorrhage into the tumor and nearby cord. The patient should be placed so that immediately after the tap he can, if necessary, be placed with the head low and feet high. The most characteristic positive finding is a yellow color of the spinal fluid, xanthochromia. The amount of protein is often so great that the fluid clots. The pressure is usually increased.

The use of contrast media is often valuable, but even more conservatism should be used in the decision to employ it. Dandy (*J. A. M. A.* 117: 821, Sept. 6, 1941) has cautioned against its use, although safer contrast media have been introduced since his protest. In cases of real doubt as to the level of the tumor the method should, of course, be employed.

In syphilitic meningomyelitis, or gumma of the spinal cord, pain of radicular distribution in the cervical, intercostal, abdominal, or sciatic region may be the first and presenting sign. (See King: *Syphilis of the Spinal Cord*, *Am. J. Syph.* 26: 336, May, 1942.)

Herpes zoster hardly presents any diagnostic problem after the eruption occurs, but in the early stages the "neuralgia" is nearly always puzzling. A fellow practitioner of mine had a herpes of the ophthalmic branch of the fifth nerve, and he told me that all he knew for about four days was that he had a headache that was meant for a horse. It may occur without eruption, or the eruption may not be found, as when it is confined to the ear canal. It is said to occur inside the bladder. The eruption may become gangrenous or hemorrhagic. Bilateral herpes zoster occurs and is not fatal, contrary to popular saying and belief. Generalized herpes occurs and is likely to be associated with leucemia or Hodgkin's disease. The condition may spread from the posterior roots to the anterior horns, causing paralysis. Carter and Dunlop have reported two such cases (*Brit. M. J.* 1: 234, 1941). Taterka and Sullivan (*J. A. M. A.* 122: 737, July 10, 1943) have collected from the literature 42 cases of herpes zoster with motor complications. The deltoid muscle was most often affected, then in point of numerical frequency the trunk muscles, abdominal muscles, and quadriceps. In 75 per cent of cases the eruption pre-

ceded the paralysis, in 25 per cent it followed. Upper motor neurone herpes has been described by Rocchi (Riv. di neurol. 11: 369, 1938) and Bruce (Rev. Neurol. & Psychiat. 5: 885, 1907).

Spondylitis pains generally of radicular distribution, but to the uninitiated resembling appendicitis, cholecystitis, etc. may occur as the result of nerve pressure by arthritis of the spine (see p. 91).

Syringomyelia.—Although in most instances syringomyelia is distinguished by loss of pain sense, under certain circumstances it may begin with an onset of pain. The possibilities of pathologic change of syringomyelia are almost limitless, and when cavitation reaches the surface of the cord and there is distention of the leptomeninges, pain results. It occurs either in the intercostal distribution or in the neck with stiffness and boring pain.

Leucemia and *Hodgkin's disease* by infiltration into the meninges may cause neuralgia, depending on the location of the lesion.

Chronic meningitis of various forms is likely to present as neuralgia. Arachnoiditis, diffuse proliferative leptomeningitis, is a chronic or subacute low grade inflammation, cystic and adhesive, the etiology of which can usually not be determined. Some are the result of trauma, some syphilitic, some old residual meningococcic meningitis, and a few gonococcic. It may be a sequel of typhoid fever, influenza, encephalitis, in fact, any systemic infection. The cystic formations are not true cysts, but walled-off collections of spinal fluid, caught by adhesions. Localized and generalized types can be differentiated. Among the local types Horrax (Arch. Surg. 9: 95, 1924) reported 33 cases resembling cerebellar tumor, and Demel (Arch. f. klin. Chir. 125: 561, 1932) reported 40 cases simulating brain tumor.

"Pain is the most distinctive symptom" (Blumstein and Baker, Ann. Int. Med. 18: 809, May, 1943); "it usually commences over one or more spinal segments and later becomes bilateral and spreads over a wide cutaneous area." It is influenced by posture. The location is, of course, dependent on the location of the meningeal involvement. Intercostal neuralgia is probably most frequent, but the foot, the arm, the neck, or the face may be the site. Sphincter control may be lost early or late. Motor involvement is usual with muscular weakness, possibly spasticity, or diminished tendon reflexes and impaired plantar reflexes.

Examination of the spinal fluid is not informative in most cases. Cells and total protein are normal in half the cases. Manometric studies show complete or partial block. Xanthochromia occurs, but rarely. Contrast media show scattered arrest of the medium at multiple levels in a majority of cases.

It is obviously a great simulator of other diseases. Probably the most difficult differential diagnosis is from spinal cord tumor.

Myelitis.—Inflammation of the cord, epidural abscess, compression of the cord from vertebral tuberculosis all cause a similar syndrome in which pain is a prominent feature. Infections may begin superficially in the skin and follow a nerve into the spinal cord, producing an abscess with necrosis. Ayers and Veits (Boston M. & S. J. 175: 865, 1916) describe such a case from a breast

abscess. Toxic degeneration of the cord from infection at a distance is described by Orr and Rows (Rev. Neurol. 5: 345, 1907, and J. Ment. Sc. 60: 184, 1914).

Sciatica.—Low back pain with radiation over the distribution of the sciatic nerve may be due to primary sciatic neuritis, focal infection, osteo-arthritis of the lower spine and pelvis, herniated nucleus pulposus of an intervertebral disk, tumor of the cauda equina, or filum terminale, occult spina bifida, the lancinating pain of tabes, dislocation or arthritis of the sacroiliac joint, pelvic disease, prostatic disease, metastatic tumor and several other rare and doubtful anomalies which have been described.

Irrespective of the cause, the symptoms and signs are very much the same. The average age of onset is thirty to sixty. The pain may be in the lower back, over the hip or sacrum, in the back of the leg, calf, knee, or toes, or most frequently all along the course of the sciatic nerve. In about 3 per cent of cases the pain is bilateral, a strong indication of tumor. The duration of pain is likely to be long, most cases lasting two months, some five years. Recurrence is common. Tenderness over the course of the sciatic nerve occurs in 90 per cent of cases. Lasègue's sign is increase of pain when the leg is raised with the knee stiff; it is almost constant. The knee jerks are usually not affected, but the ankle jerks are diminished or absent. Objective sensory changes are conspicuously absent, except diminished sensation on the dorsum of the foot.

Every case of any severity should have the benefit of an x-ray picture of the lower spine and pelvis. If any doubt exists, an examination of spinal fluid, especially for the Wassermann, should be made. Contrast media injections of the spinal canal should be considered in doubtful cases, especially those in which herniated nucleus pulposus is suspected. The procaine test is applied to those patients who have a definite "trigger point." The trigger point is marked, and a long spinal puncture needle is inserted through it until the periosteum is reached, or the patient admits the characteristic pain of the trigger point and radiation. Then 5 to 10 c.c. of 1 per cent procaine is injected. Temporary relief from pain on movement is acknowledged by the patients.

The relative frequency of the causes of sciatica is a subject about which there is little agreement. The cases due to tumor, etc., occur in quite fixed proportions in any large clinic, but the "idiopathic" cases are the ones that give the trouble. Long ago it satisfied clinical judgment to call them sciatic neuritis. Then came a wave of investigation of sacroiliac disease and later of osteo-arthritis, and most cases were ascribed to those causes. In 1934, Mixter and Barr (New England J. Med. 211: 210, 1934 and Ibid. 213: 385, 1935) called attention to the frequency of a herniation of the nucleus pulposus of an intervertebral disk as a cause of sciatica. Since then the tendency has been to ascribe most cases to this cause. Reports, however, are very coy about giving statistics. Hyndman, Steindler and Walkins (J. A. M. A. 121: 390, Feb. 6, 1943), after studying 117 patients with low back pain, state that, "We do not believe that herniated disk is the only cause of referred sciatic pain, but it is

the most common cause." Love and Walsh (J. A. M. A. 111: 396, 1938) state, "It is quite as antiquated to make a diagnosis of 'sciatica' today as it is to make a diagnosis of 'headache.'" Both reporters avoid exact figures. My friend, Dr. Frank D. Dickson, an orthopedic surgeon of wide experience, says that 4 per cent of sciatica cases are due to herniated nucleus pulposus.

Such discrepancies can be ascribed partly to difference of material. Drs. Love and Walsh work at the Mayo Clinic and the run of cases at Shangri-la is likely to differ from the jungle of average practice.

Alpers, Gaskill, and Weiss (Am. J. M. Sc. 205: No. 5, May, 1943) made a good argument for the reality of primary sciatic neuritis as an entity. This is a healthy corrective doctrine although the obvious danger is that in voting too quickly for a "primary sciatic neuritis," serious organic causes of sciatica will be overlooked and neglected.

Herniated nucleus pulposus occurs in 90 per cent of cases at either the fourth or fifth lumbar intervertebral space. It is usually the result of trauma which may, however, be very trivial. The annulus fibrosus is ruptured, the soft central cartilage is extruded and compresses the adjacent nerve root against the over-lying ligamentum flavum or the borders of the intervertebral foramen. The symptomatology is classical for sciatica, but cases have been reported in which anesthesia of the perineum and loss of sphincter control occurred. The use of iodized oil or other contrast media in the spinal canal usually gives a recognizable filling defect if herniation is present.

Unilateral rupture of the sixth cervical intervertebral disk produces a syndrome resembling coronary thrombosis, pain in the neck, shoulder, arm, and precordium. (See Semmes and Murphy: J. A. M. A. 121: 1209, April 10, 1943.)

Tumors of the cauda equina, conus and epiconus medullaris often run a long clinical course and are very infrequently recognized. The malignant forms, endothelioma and glioma, are usually encapsulated so that their growth is slow. Neurofibroma occurs perhaps a little more frequently than the malignant forms. The first and presenting symptom is usually sciatica and low back pain and the patients often drag on for months and years with this diagnosis. Spiller and Frazier reported (Arch. Neurol. & Psych. 8: 455, Nov., 1922) that the average duration of the disease before diagnosis was made in their series was two and three-fifths years. A peculiarity of the pain of caudal tumor is that walking affords relief and the prone position aggravates it. The onset of the more characteristic and distinguishing triad of symptoms—sphincter disturbance, atrophic paresis of the lower limbs, and perianal ("saddle") anesthesia—should inevitably suggest the diagnosis. Trophic ulcers are common. The spinal fluid shows xanthochromia and increased pressure below the tumor level, but Ayers showed that these are also present very often above the level.

Tumors of the filum terminale are rare. Sphincter disturbance is likely to precede all other symptoms. (See good discussion by Sachs, Rose and Kaplan: Arch. Neurol. & Psych. 24: 1133, Dec., 1930.)

Meralgia paresthetica (Roth's or Bernhardt's disease) is a rare condition, consisting of pain, paresthesia, etc., over the front of the thigh. Occupation (shoemaker, clothes presser leaning against his ironing board) and pressure, as from too low a corset, are given as causes. A neurotic background is usually demonstrable. (See Goldstein: *Am. J. M. Sc.* 162: 720, Nov., 1921.)

Neuralgia of the lateral brachial cutaneous nerve is distributed to the skin over the outer aspect of the arm and over the lower two-thirds of the deltoid region. It is usually caused by pressure from crutches or fracture of the neck of the humerus.

B. Anesthesia—Pain, Temperature, Proprioceptive and Vibratory Senses

Loss of the sensation of touch may be local, confined to the distribution of a sensory peripheral nerve, or have a segmental distribution suggesting the involvement of a spinal root segment or a paraneesthesia, the complement of a paraplegia anesthesia of the lower half of the body, indicating a spinal cord disease, or hemianesthesia indicating involvement of one optic thalamus, or the bizarre distribution of hysteria. Individuals vary in their reactions to anesthesia—some do not mind it, in fact, hardly know it is there, to others it is as troublesome as pain. Janet relates the case of an hysterical girl who had an anesthesia of the entire left side which she did not complain of at all, but when her median nerve was severed and she got an organic anesthesia of the fingers and thenar eminence she complained bitterly.

Anesthesia of the face is not common. Of course, it occurs after operation on the gasserian ganglion. But anesthesia due to spontaneous disease of the nerve is confined to rare cases of tabetic degeneration of the nerve or chronic (usually syphilitic) meningitis. While syringomyelia usually affects only pain and temperature modalities, touch may also be involved and loss of sensation over half the lower part of the face and the cervical region is one of the rarer syndromes of the disease.

The auriculotemporal nerve may be involved in abscess wounds or in any disease of the parotid gland, and causes anesthesia of part of the scalp and face over the zygoma. As regeneration begins, a peculiar symptom makes its appearance—whenever the patient eats food that is bitter or sour there is sudden redness, warmth and appearance of beads of perspiration over the area supplied by the nerve.

The peripheral nerves of the arm are seldom injured or diseased so that the sensory fibers alone are involved. The radial nerve is most frequently involved because it is likely to be injured by fractures or dislocations of the humerus, crutch pressure, etc., but there is so much overlapping of skin distribution from other nerves that loss of sensation is rare. The median nerve, however, when injured is likely to show a very troublesome loss of sensation in the palm of the hand and the volar surface of the index, middle, and half of the ring finger. Ulnar injury causes loss of sensation over the outer part of the hand, front and back, the little and half of the ring finger.

Tabes dorsalis sometimes in its course almost invariably produces one or more zones of anesthesia of radicular distribution: girdle bands about the

chest or abdomen, or over the outer side of the leg and foot, or inner side of the arm or hand. A faulty ability to locate touch accurately is an extremely characteristic sign of tabes.

Leprosy, when the nerves are involved, produces muscular patches of *anesthesia which are de-pigmented*. The fifth nerve is most frequently involved, but any of the peripheral nerves may be. Leprosy is selective for the sensory fibers.

Perianal, or perineal anesthesia may at times be extremely important to determine. Hematomyelia of the sacral segments of the cord may result from falls, etc., even though there be no fracture, and produce a transient paraplegia, and a stubborn residual perianal anesthesia which causes reflexly sphincter disturbances. Tumors of the cauda equina (q.v.) will do much the same thing.

Spinal Cord Tumor, Hemorrhage, Transverse Myelitis.—The zone of anesthesia in these conditions has been discussed under the headings of Spinal Cord Tumor and Myelitis (p. 597 and p. 599).

Syringomyelia, syringobulbia, or spinal gliosis consists of the production of cavities in the cord or bulb due to increase and proliferation of glial cells. In the cord the process results usually in an increase in size of the central canal; in the bulb around the place of the fourth ventricle. The cavity encroaches on various structures, producing symptoms depending on the structures involved. Usually due to the anatomic placement of the spinal pain and temperature tracts there is loss of pain and temperature sense with preservation of tactile sense, but the nature of the process leads to quite a variety of symptoms, motor and trophic as well as sensory. Depending on the location and distribution of the gliosis, it is possible to describe a relatively few syndromes characteristic of syringomyelia.

The disease is apparently much more common on the continent of Europe than in England or North America. Schlesinger, in Germany, stated that it was the commonest of spinal diseases, but at the National Hospital, Queen's Square, London, the admissions of syringomyelia were 1.6 per cent of all admissions, many spinal diseases, such as multiple sclerosis, spinal cord tumor, tabes, etc., exceeding it. For the United States I find no statistics. It is almost certainly an hereditary familial disease. It has been produced experimentally in inbred rabbits. It is often accompanied by bodily deformities, such as polydactylism or spina bifida, or a condition known as *status dysraphicus*. The age of onset is young, on the average fifteen to twenty-five years, and males greatly predominate.

The usual history which directs the patient's attention to the fact that there is something the matter with him is that he burns himself and is unaware that he has come in contact with a flame or hot object. But, depending on the extent and location of the gliosis any sensory or motor symptom controlled by the cord or bulb may be involved. They can be conveniently grouped in syndromes.

Bulbar Syndrome.—Symptoms may be acute in onset, but are usually gradual. Swallowing or phonation is affected. Impaired equilibrium is often noted.

Persistent hiccup, trigeminal neuralgia, rotary nystagmus, syndrome of Avellis (see p. 557), and abolishment of taste are rare.

Cervical syndrome may be bilateral or predominantly unilateral. Dissociated anesthesia is the commonest sign—pain and temperature lost, tactile sense preserved, but tactile anesthesia may also be present. Neck, arm, and shoulder are involved. Amyotrophy is common, resembling amyotrophic lateral sclerosis of hand and arm. Limb may be partly atrophic, partly spastic. Trophic changes include ulcers of fingers (Morvan's disease) and hypertrophy of bones of hand and arm, requiring differential diagnosis from acromegaly. The succulent hand is due to vasomotor changes.

Lumbosacral syndrome is dissociated anesthesia of leg and foot, with atrophic weakness of the limbs, loss of deep reflexes, sometimes defect of sphincter control, or spasticity with positive Babinski, club foot and trophic ulcers, painless felons, sometimes even Charcot joints.

Multiple Sclerosis.—Sensory symptoms are not common in multiple sclerosis, but, of course, may occur, depending on the location of the development of a spot of sclerosis. Both cutaneous and deep sensibility may be impaired, usually with the accompaniment of astereognosis.

Hemianesthesia. The Thalamic Syndrome.—Dejerine and Roussy (Rev. neurol. 14: 521, 1906) described the thalamic syndrome as follows: "When there is a lesion of the thalamus, the patient shows a transitory and rapidly retrogressive motor hemiplegia, without clonus or Babinski sign. This hemiplegia is accompanied by disturbances of sensibility, both subjective and objective; subjectively these consist of pains on the paralyzed side, which are lively and tenacious, not yielding to any treatment, and constituting by themselves a real impotence (painful hemiplegia). Objectively they consist of a hypo-esthesia for sensations of touch, pain, and temperature; sometimes of hyperesthesia with dys-esthesia, paresthesia and topo-esthesia, finally of persistent disturbances of deep sensation, of loss of muscle sense, of astereognosis and of hemiataxia. Often also choreo-athetoid movements appear. Hemianopsia may be met with in cases in which the lesion involves the posterior and inferior part of the thalamus."

The thalamus is the great relaying station for all sensory fibers to the cortex. All ascending impulses which continue to the cortex synapse at the thalamus. This explains why disease of one thalamus results in a hemianesthesia, and obliteration or partial obliteration of pain, temperature, and deep sensibility. The thalamus lies next to the internal capsule and striate bodies, and hemorrhage or tumor in the thalamus would cause swelling which would account for the hemiparesis and the athetoid movements. Both of these, however, are likely to be transient. The active sensation of pain down one side of the body is likely to appear last in the clinical course of the thalamic syndrome. It may not be pain, but a disagreeable feeling which the patient cannot describe.

It is sometimes described as boring, or tearing. One of Percival Bailey's patients refused to allow the nurse to wash the affected side of his body or the barber to shave one side of his face.

Thrombosis of the posterior cerebral artery produces the most characteristic examples of this syndrome. (Foix and Masson: *Le syndrome de l'artère cérébrale postérieure*, La Presse méd. 1: 361, 1923.) Tumors are rare, gumma and tubercle possible.

Cortical Anesthesia.—The zones of the cerebral cortex from which disturbances of sensation may originate are the posterior central gyrus, the superior parietal lobe, and the supramarginal gyrus, at least in part. Tumors of the parietal lobe produce a hemilateral change in sensation, not so much tactile sensation as sense of position or movements of the limbs—the proprioceptive senses. Astereognosis is also present. Tactile sensation is indeed diminished, but it requires time and patience to demonstrate it, as it may not be evident at all on a hasty examination with a wisp of cotton. Aphasia of some sort and often Jacksonian convulsions are also usually present in parietal lesions. (See Head: *Sensation and the Cerebral Cortex*, Brain 41: 57, 1918, and Head and Holmes: *Sensory Disturbances From Cerebral Lesions*, Brain 34: 102, 1911.)

Occlusion of the basilar artery usually produces death too promptly for any symptoms to be recorded. In the few patients who survive, a quadriplegia and *total loss of sensibility* are found.

Occlusion of the posterior inferior cerebellar artery produces violent vertigo, pain of the upper part of the face, difficulty in swallowing, and paralysis of the soft palate. The residuary sensory symptoms are peculiar: appreciation of pain and temperature with loss of tactile sensation and limb position on the opposite side of the body, and analgesia and thermo-anesthesia on the same side of the face as the lesion.

Hysterical Anesthesia.—Charcot said that anesthesia was the primary stigma of hysteria.

I find of late a curious reluctance on the part of neurologists to come out and call the name hysteria. For instance, in a book of S. H. Kraines, *The Therapy of the Neuroses and Psychoses*, published in 1943, hysteria receives no separate mention or definition. The same is true of Dr. Julius Gunkel's *Neurology*, 1943 edition. The modern psychotherapist, intent on the personality problems of the neuroses, discusses them on the basis of etiology and lets them run together into a fluid whole. In the case of hysteria, at least, this seems to me retrogression rather than progress. Hysteria is a distinct clinical entity, quite as distinct as dementia precox or paranoia, it should be recognized and separated by the clinician because it has a special prognosis, a special psychology, and, I am not sure but that it has a special etiology. I would dare to paraphrase Osler's famous dictum and say that when a student knows hysteria and syphilis thoroughly all things clinical will be added unto him.

The most helpful conception of hysteria for the clinician seems to me to be that of Pierre Janet, whose *Major Symptoms of Hysteria* I read when a student, as long ago as 1907, and which I have recommended to successive generations of medical students. Janet said that hysteria is an amnesia—a forgetfulness. One person with hysteria will have a dissociated personality—A forgets B, and B forgets A. Another forgets how to see—hysterical blindness. Another forgets the movements of the arm—hysterical paralysis. An-

other loses all sense of proportion, puts on a domestic scene—and her mother says, “You have forgotten yourself.”

In the case of the anesthesia, Janet made an acute observation. The hysterical anesthesia, say of a hand, stops at the wrist; now we know the nerve supply to the hand makes such a thing impossible; but the hysterical person has “forgotten” the mental conception of a hand, therefore the feeling stops at the wrist.

Janet dressed this up by calling it “a retraction of the field of consciousness,” but I think amnesia or forgetfulness is a more vivid term. It has not made the slightest difference to me through the years whether this conception can be proved. All I claim for it is what I said above, that it is the most useful clinical conception of hysteria I know.

A favorite definition of hysteria is that it consists of increased suggestibility, or is “an irrational answer to a conflict.” Those definitions would be true of any neurosis, and would apply to any neurotic person; in fact, to a great many quite normal persons. If increased suggestibility applied only to those with hysteria, the advertising business would be in the same category as the dancing teacher who specialized in the polka.

With this definition in mind it is possible to select patients with hysteria from the rest of the group of neuroses. Pain, for instance, so often given in textbooks as one of the stigmata, is not a symptom of hysteria, irrespective of the *clavus hystericus*, etc. Janet does not mention pain in any of his writings on hysteria. Pain is the opposite of an amnesia. If it occurs in a person with hysteria, it is a complication of another neurosis. But anesthesia, paralysis, amblyopia, aphonia, somnambulism, fugues, dissociated personality, contractures, convulsive attacks, rhythmic purpose movements (like the salute of Charcot's patient who every so often sat up in bed and bowed her forehead to her knees)—all these fit into our conception perfectly.

Hysteria is a relatively rare disease. Compared, certainly to the other neuroses, which form the bulk of a general internist's practice, I do not feel that the other neuroses are capable of such strict definition. Neurasthenia, for instance, seems to me now a meaningless term. They can profitably be lumped together on the basis of a common etiology—a neurotic personality, the will to be sick, the irrational resolution of a conflict, the Oedipus complex—whatever you will. *In conclusion I would state my belief that hysteria is more of a psychosis than a neurosis.*

III. COORDINATED FUNCTIONS

A. Speech

Aphasia.—Broca located the motor center for speech in the third left frontal convolution. Wernicke located the sensory center in the superior temporal gyrus. The center for reading is in the angular gyrus, for writing in the precentral gyrus. Destruction of Broca's center alone results in inability to form articulate speech—the muscles of phonation are all right, but the subject suffers an intellectual difficulty in forming sentences, perhaps a memory

defect. He can understand words spoken to him. With the destruction of Wernicke's center, which lies in the auditory region, he cannot understand what is said to him.

This rigid theoretical charting was challenged by Marie who considered that all aphasia is an intellectual defect and not strictly localized in the cerebral cortex. It is not possible here to go into the theoretical conceptions of the condition; they have been ably stated by Head, and the student who desires further enlightenment is referred to those writings (Head: *Aphasia and Kindred Disorders of Speech*, The Macmillan Co., 1926).

I can explain certain cases of aphasia I have seen no other way than by the original conceptions of Broca and Wernicke. A right-sided hemiplegia, which would mean the lesion is in the left cerebrum, is accompanied by pure motor aphasia, accompanied by graphia and alexia. But they have no sensory auditory aphasia. One such patient, a physician with a fluent command of language, a distinguished author and omnivorous reader, could not, after his stroke, formulate a single sentence either in speech or writing, or understand a printed page. He understood everything that was said to him and indicated such understanding by nodding or shaking his head. He was perfectly capable of playing *solitaire*, which was tragically his sole occupation for fifteen years before his death. He attended surgical operations in the amphitheater of the hospital where he stayed, voluntarily assumed a visitor's gown and never attempted to break the routine of asepsis, and indicated his understanding of the nature and purpose of the operation. In other words, he had no sensory aphasia and no intellectual defect.

Cerebral tumors on the left side near the frontal convulsion result in a similar speech defect, although there are many forms of partial aphasia associated with cerebral tumors. Head has called attention to a slowing up of speech in such cases, which he thinks is a precursor of complete aphasia.

Localization of a lesion in the left cerebral speech center results in aphasia in right-handed persons. There is considerable evidence to show that in left-handed persons Broca's center is in the right cerebrum, and I have seen one left-handed person who had a left-sided hemiplegia with motor aphasia. I have never been able to find the account of a similar case in the literature.

Sensory aphasia, word deafness, results from tumor in the parietotemporal lobe. A frequent accompanying or preceding symptom is astereognosis. Possibly also Jacksonian fits, or subjective sensory phenomena.

Scanning speech is one of the Chareot triad of multiple sclerosis, but is more often conspicuous for its absence than for its presence.

Slurring speech, running together of consonants, is a fairly specific sign of early (and late) general paresis.

B. Equilibrium

Disorders of equilibrium include not only vertigo, but inability to stand or walk purposefully and inability to make many purposeful movements—for instance, button and unbutton the clothes, pick up an object on the floor or on the table before which the patient is seated.

Acute alcoholic intoxication is a good enough example of disturbance of equilibrium to illustrate at least that perfect equilibrium is a coordinated function. The drunken person's vision is disturbed; he sees double or triple; his organs of equilibrium, the semicircular canals, are not functioning (give him an amateur Bárány test by spinning him around and when you let go of him he is lost in an impenetrable forest); his muscles have lost coordination and he fumbles at his buttons, he cannot grasp even a glass without bracing his body and arms; he pulls a coin out of his pocket and drops it on the floor. Yet his motor reflexes and tactile responses are likely to be quite normal; he has no paralysis of the muscles, and if you can get him to respond at all he can determine the position of his fingers, toes, feet, hands, legs, etc.

Scattered as the functions are which enter into equilibrium, they can, however, be fairly well localized, because in the cerebellum we have the great coordinating organ of labyrinth, ocular and muscular functions. The acute alcoholic subject has poisoned his higher nervous cells quite diffusely, but it would be a safe theory, although we have no evidence, that in the stage of ataxia his cerebellar cells are more profoundly affected than any others.

Turning from the pathologic condition of the drunken person, let us consider the marvels even the humblest of us perform daily and hourly in the field of equilibrium. I am playing golf and I am, at the moment I am describing, about to hit a golf ball with the end of a club. The golf ball, in the first place, is quite a small object, a sphere only a little over an inch in diameter. The face of the club is also quite small. My feet are about two or three feet from the ball. I am in no physical contact with it whatever. The face of the club is far from my body, controlled only by my hands. Yet I must bring, not only the face, but the center of the face of the club, not only into contact with the ball, but with a spot geometrically opposite the exact center of the ball. I do not claim that I always do this; but I do it perhaps two times out of three, and that I do it at all, seems to me sort of automatically marvelous. It is a triumph of my cerebellum. I am able to hold my body in a certain poise—my stance included maintaining a tonus of my muscles, a correct sense of what my joints are doing, and of course, my semicircular canals are working like fury all through my swing. My vision is also involved; I have to keep my eye on the ball, or at least so I am told on the highest authority, and all of these sensations and volitions are coordinated in the cerebellum, both by centripetal paths and the centrifugal paths of synergic control of the muscles.

Temporary acute vertigo is a sensation which few people have gone without experiencing. Intoxications, acute infections, or simply sudden changes in posture or vigorous exertion which involves whirling, as in dancing, overheating of the body as from a prolonged hot bath, or sunbathing—many such causes will bring it on. The elderly with their less responsive cerebral arterial system are particularly subject to spells of dizziness. Continuous recurrent or chronic vertigo occurs in Ménière's disease, cerebral arteriosclerosis, cerebellar disease, or increased intracranial pressure.

Vertigo, *per se*, can be found without complete disturbance of equilibrium. It is really a function of the labyrinth not necessarily implying any disturb-

ance of the cerebellum. Stewart and Holmes (Brain, 1904) tried to differentiate vertigo into the two forms—in one of which external objects pass in rotation, and the other in which the patient's body seems to be spinning. The first form they thought was due to cerebellar disease; the second had no localizing value, but experience does not bear out this differential test. Wilson and Pike (Arch. Int. Med. 15: 31, 1915) made a sounder distinction: "Labyrinthine lesions differ from cerebellar: (1) in the existence of Romberg's sign in labyrinthine lesions; (2) variations in the attitude of the head influence, the lack of equilibrium of the body in labyrinthine and not in cerebellar lesions; (3) an affection of the labyrinth does not definitely involve those movements of isolated parts which result in dysmetria; (4) in labyrinthine disease movements of rotation or disorientation are not so readily perceived."

Ménière's syndrome is the only common severe form of vertigo. It is probably strictly labyrinthine, or at least eighth nerve, in origin. The attacks are recurrent, come on suddenly with such severe vertigo as often to throw the patient to the floor. In true attacks the patient always seeks his bed, prefers to be in the dark and even hangs on to the bed, so severe is the sense of dizziness. Vomiting and nystagmus occur during the attack. Tinnitus accompanies, precedes, and follows the attack, and may be the inaugural symptom of the disease. Progressive deafness is the rule. Between attacks the only residual sign may be Romberg's.

The etiology is obscure. The age incidence, always above fifty years, 75 per cent above sixty, is significant of vascular change in the labyrinth. Dandy argues that the lesion must lie in the eighth nerve rather than in the labyrinth, on the basis that the progressive deafness always follows the onset of the vertiginous attacks, so both cochlea and semicircular canals are involved. Section of the eighth nerve invariably brings relief. He compares it to *tic douloureux* of the fifth nerve. Furstenberg, Lashmet, and Lathrop (Ann. Otol. Rhin. and Laryng. 43: 1035, 1934) found a change in the electrolytic balance, but the salt-free diet they recommended is of little practical therapeutic benefit.

Syphilis may affect the eighth nerve. Stokes lists vertigo from this cause as one of the early signs of neurosyphilis.

Cerebellopontine angle tumor is the commonest intracranial tumor. Its exact site of origin is probably always the eighth nerve. When the tumors become large, the relationship may be impossible to determine, but when seen early while they are small they always arise from the nerve. Histologically they are neurinomata. They grow slowly and are not essentially malignant. Sooner or later they nearly always involve the sixth nerve, and often the seventh and ninth. The symptoms of onset are nearly always tinnitus and deafness, which may precede by several years the strictly cerebellar signs. Paralysis of the external rectus is almost invariable, and involvement of the glossopharyngeal causes paralysis of the tongue and swallowing difficulty. Involvement of the fifth nerve causes hyperesthesia and anesthesia of the cornea, and occasionally symptoms resembling *tic douloureux*. Spasms and twitching of the face indicate involvement of the seventh nerve. The strictly cerebellar signs are likely to be the last to appear. The patient drops things

from the hand frequently and regularly, although involvement of the upper extremity is not as frequent as involvement of the lower. The gait becomes unsteady and reeling, and there is a tendency to fall toward the side of the tumor. Vertigo may be very troublesome or in some cases absent. There is stiffness in the muscles of the neck and a tendency to hold the head tilted toward the side of the lesion. Finally there is headache, dimness of vision, and vomiting. The cerebellar signs (past pointing, asynergia in buttoning, unbuttoning and adiadochocinesia, or dysdiadochocinesia) can usually be demonstrated by the limb on the side of the lesion. Hemiparesis with exaggeration of the reflexes on the opposite side from the lesion, in later stages of the disease due to pressure on the bulb.

The Bárány tests are quite valuable in the early stages of growth. In irrigating the ear on the side of the lesion, no reaction is obtained from either the vertical or horizontal canals, while upon irrigating the opposite ear the horizontal canal reacts, but the vertical canals do not. It is possible to have a bilateral acoustic tumor, and it may occur in combination with generalized neurofibromatosis.

Glioma of the *pons* may imitate a cerebellopontine tumor, but the differential points are that the gliomas tend to occur in children and the signs are more frequently bilateral.

Tumors of the cerebellum itself are not so likely to involve the cranial nerves, and cerebellar ataxia and vertigo are likely to appear first. Headache, choked disk, and vomiting (signs of intracranial hypertension) come on soon after the first symptoms.

Primary paleocerebellar atrophy is a rare hereditary disease, which comes on in the fifth decade. The patient complains always and first of difficulty in walking, but when analyzed, this turns out to be a difficulty of equilibrium. He can stand only by keeping his legs wide apart and he weaves backward and forward. He walks with a spraddling gait, with many little hesitations and side excursions, and a tendency to fall backwards. (See Marie, Foix and Alajouanine: *Rev. neurol.* 38: 849 and 1082, 1922.)

IV. MENTAL STATES DUE TO ORGANIC DISEASE

It is not my purpose to describe the psychoses in this volume. But deviations from a normal mental state may be due to organic disease, and these I must mention briefly.

A. Disorientation, Confusion, Character Change, Dementia

Brain Tumor.—Four places in the brain are not uncommonly the site of tumors, and when they are destroyed or diseased by tumor, injury, or (rarely) abscess, a clinical picture of mental disorientation results. They are the frontal lobe, the hypothalamus, the corpus callosum, and the left supramarginal gyrus in the parietal lobe. This statement refers to specific and localizing symptoms, not to general global mental deterioration that results from intracranial pressure irrespective of the location of the tumor. When intracranial

pressure becomes high, the patient always becomes dazed, apathetic, and confused. All the mental functions are slowed. He rubs his head, yawns, and rubs his nose, and pays no attention to his surroundings unless strongly stimulated. This may go over into coma. But such a state has no localizing value. Tumors arising at the sites mentioned, however, produce the mental symptoms first, and they are likely to be the presenting symptoms the patient's family relate.

The onset of symptoms of a tumor in the frontal lobe is often insidious, made apparent more so in that the first symptoms themselves are vague. Forgetfulness is likely to be one of the first. A man is unable to retain a grasp of the details of the transactions of his business. A woman will forget to do her household duties or her marketing. Sometimes this worries them, more often they are indifferent and become more so. They grow taciturn and solitary. They show lack of judgment. Disorientation as to place is definite and questions to bring this out should be made a matter of record. Injuries of the frontal lobe, among the commonest of cranial war injuries, bring this out especially; in the injuries, according to Dr. Percival Bailey, the disorientation as to place is more profound than in any frontal lobe tumor. This state is often replaced by one of silly euphoria. Social lapses, such as appearing in public improperly dressed, exhibitionism, etc., are regarded by the patient as very cute. He uses wisecracks in answer to questions. Dr. Percival Bailey, in his excellent work, *Intracranial Tumors*, gives a typical conversation between such a patient and his doctor:

"How do you feel this morning?"

"With my fingers."

"I mean, do you feel well enough to go home?"

"Don't you think I would look better in the ash can?"

"Will your wife not be glad to see you?"

"Oh! we have been married a long time; her ardor has cooled off."

"Why did you come to the hospital?"

"That's why. 'To get my battery charged.'"

A characteristic physical sign of frontal lobe tumor is reflex grasping and groping. The patient seizes on an external object and hangs on. Nurses often have difficulty caring for these patients because they hold the bedclothes, and in feeding hold the food or spoon so tightly they cannot get it to the mouth. Then they indulge in spells of pointing, movements of the hands and fingers, groping, etc. (See Freeman and Crosby: *J. A. M. A.* 93: No. 1, July 6, 1929.)

Note that there is no aphasia—motor or sensory. The mental symptoms of tumor of the left supramarginal gyrus are directly dependent upon aphasia and agraphia. The patient cannot formulate a sentence or write one, although he can repeat words or copy them in writing. He speaks of himself in the second person (agrammatism), repeats the same word (perseveration), and misuses words (paraphasia). He has difficulty in manipulating common objects (apraxia). It is not unnatural that on this basis his whole mental status deteriorates. It is quite different from the sudden motor aphasia of hemiplegia, in which the mind, so far as we can judge, remains quite clear.

The corpus callosum is the association pathway between the two cerebral hemispheres. Glioblastoma selects the corpus callosum quite definitely, although rarely as a site of growth. The symptoms are mental, as would be expected. Progressive dementia, apathy, drowsiness, and loss of memory are the symptoms usually most pronounced.

Tumors of the hypothalamus are characterized by the symptoms of extreme somnolence. Inversion of the sleep rhythm is a form of somnolence perversion often seen in these cases. Since growth or irritation in the region of the third ventricle is particularly likely to produce fever, these cases are often mistaken for encephalitis. Polyuria (diabetes insipidus) is a regular accompanying symptom. (See Fulton and Bailey: *J. Neur. & Ment. Dis.* 69: 145, 1929.)

Cerebral Arteriosclerosis.—In a series of cases of cerebral arteriosclerosis the commonest symptom was vertigo. Next commonest were mental symptoms. Headache and difficulty in walking were next. The mental symptoms can fall into nearly any pattern—disorientation, confusion, character change, hallucinations, etc. One patient constantly got lost in his own house and thought the roar of the near-by elevated was cannonading. Commonest is dementia of gradually deepening severity, senile dementia. Forgetfulness is a frequent initial symptom. Depression and melancholia are familiar attitudes of old age. Lack of judgment and excitable impulses are only too well known to expectant heirs who have to contemplate the marriage of some octogenarian or watch him sell his property at sacrifice prices for no good reason. It must be remembered, moreover, that cerebral arteriosclerosis may produce symptoms at a fairly young age period.

General Paresis. General Paralysis of the Insane. Late Syphilis of the Cerebral Cortex.—This is still a frequent clinical entity although like all late syphilis it is gradually disappearing. Mental symptoms predominate throughout its course, although they change in any individual in the course of progress of the disease. The forms of psychoses are *expansive, agitated, depressed, and demented*. The onset may be gradual, with clouding of consciousness, forgetfulness, and poor judgment, or somewhat explosive, although careful inquiry from the family about the explosive type will usually reveal a period of gradual character change, the significance of which is lost. Gradual dementia is the commonest course. The agitated paretic has delusions of grandeur and spells of poor judgment, embarking on business enterprises of an impossible kind. All their enterprises are not necessarily failures, however; one of my patients made about a million dollars during six weeks in oil well transactions. The excited or agitated paretic is dangerous, often homicidal, always combative.

The *signs* of paresis are slurring speech, tremor, illegible writing, and difficulty in gait. About 30 per cent of all paretics have tabetic cord changes with Argyll Robertson pupil, positive Romberg, ataxic gait, etc. The pupils of most paretics show change, irregularity or dilation, with extremely active response to light.

B. Stupor, Somnolence

Abnormal sleepiness or stupor which differs from coma in that the patient can be aroused to some extent, occurs in many infections and toxic states, particularly in encephalitis, meningitis, and trypanosomiasis; also in disease of the hypothalamus, as mentioned above (p. 612), brain abscess, subdural hematoma, subarachnoid hemorrhage, and pachymeningitis hemorrhagica interna. Among the toxic states which the hospital attendant should remember nowadays is overdosage with the all too popular barbiturate hypnotics.

Epidemic encephalitis is a disease with which the modern clinician has been familiar only since 1916. Whether it had ever been described before, or whether it had ever existed before then is debatable, but certainly the statement is correct that it was not familiar to clinicians previously. The epidemic started in Austria in 1915, or at least was first recognized and described there by Economo, and rapidly spread all over the world. In 1920 it was estimated that there were 10,000 cases, and in 1924, the year of the Japanese epidemic, there were 17,000. The first cases recognized in the United States were described in 1918. It continued in pandemic form in this country until about 1925. In 1933, and again in 1937, a widespread and severe epidemic occurred in and around St. Louis. The various epidemics show individual variations in symptoms; thus, the first cases were the somnolent form, "sleeping sickness." Later, bulbar and still later hyperkinetic syndromes predominated. The St. Louis type imitated meningitis—fever, nausea, vomiting, positive Kernig sign, lethargy.

The lethargic stuporous, somnolent forms come on usually with great suddenness and without distinct prodromes. The sleep may range from deep and continuous to light and intermittent. It may last for days or weeks, or even at intervals for years. Fever of some degree is present at least in the early stages. In this form cranial nerve involvement is common, especially of the oculomotor nerves with ptosis, diplopia, strabismus, nystagmus and oculogyric crises. Leucocytosis is generally absent. The spinal fluid does not show very marked changes—cell counts of 10, 20, rarely up to 200, sugar increased, globulin little, if at all, increased, colloidal gold curve of syphilitic type.

Abortive cases of all clinical types with minimal manifestations are common, especially in the midst of an epidemic.

Other forms are those with predominantly psychic, labyrinthal, atoxic bulbar, meningeal, spinal (resembling poliomyelitis) neuritic, hyperkinetic or myoclonic manifestations. Cases resembling myasthenia gravis and multiple sclerosis have been described.

Postencephalitic Parkinsonism has already been described (p. 585).

Narcolepsy has been observed as a sequel and sometimes a late sequel of the cases of encephalitis of the 1925 epidemic.

Encephalitis, pathologically resembling epidemic encephalitis, is a possible sequel of a number of infections, most of them classified as virus diseases—measles, chicken pox, smallpox, vaccinia, German measles, mumps, scarlet fever, typhoid and typhus fever.

Meningitis of any form will usually begin with a stuporous state. It is what calls attention to the patient and convinces relatives or companions that he is sick. Coma may supervene. In the midst of an epidemic of cerebrospinal meningococcic meningitis such states demand immediate investigation; the eruption often does not appear for several days afterwards.

Brain Abscess.—The common causes of brain abscess are (1) extension of mastoid suppuration, (2) metastatic from lung infection (lung abscess, empyema, bronchiectasis, etc.), and (3) as part of a general pyemia.

The recognition of the existence of an etiologic factor is probably the most important element in diagnosis because the symptoms of onset are notoriously vague and insidious. Ninety per cent of cases are due to suppurative ear or mastoid disease. Most cases occur before the age of thirty. The close relationship between pulmonary suppuration and brain abscess is not readily explained, but is very definite, none the less.

The location of brain abscess following ear or mastoid suppuration is in the temporal lobe in 66 per cent of cases, in the cerebellum in 32 per cent, and multiple or scattering in the rest. Abscess from pulmonary suppuration lights in the centrum semiovale of the brain most often, in the cerebellum next most often.

In a patient with the proper etiology the onset of either a gradual or sudden dimming of intellect should be enough to make one suspect brain abscess. The patient may be drowsy, listless and inattentive for days before the onset of deep stupor and coma. Very occasionally fits of irascibility and excitement may interrupt the dimming mind.

Localizing signs are not always reliable, but if present they are about the same as the localizing signs of brain tumor. Signs of intracranial tension may or may not be reached. Papilledema is far less common than in brain tumor; statistics from different clinics show considerable variation as to its incidence—from 66 to 30 per cent.

Chronic, Nonsuppurative or Hemorrhagic Meningitis.—There are many forms of subacute or chronic change in the meninges, not at all infrequently found at autopsy and seldom accurately diagnosed or even suspected during life. They go under the names of pachymeningitis hemorrhagica, subdural hematoma, brachnoiditis, and a half dozen others. Hemorrhage is a common finding. The etiology is very difficult to explain. Trauma is brought out in the history sometimes, but not severe trauma, not severe enough to cause skull fracture. Alcoholism is mentioned, as well as syphilis, although either typical syphilitic meningitis or the sequelae of suppurative meningitis is excluded by definition from this group.

Pachymeningitis hemorrhagica interna is a common finding at autopsy, especially in institutions for mental cases, aged, and alcoholics. It is definitely not traumatic. It has been quite generally considered of pathologic rather than clinical interest, but many cases can be found among persons who are not institutionalized, not alcoholic, and in young or middle life.

The key to the diagnosis is as follows: a person somewhat suddenly becomes ill with headache and vomiting and lapses into stupor or coma, and a

bloody spinal fluid is found. (See Dunn: Pachymeningitis hemorrhagica interna, Am. J. M. Sc. 163: 819, June, 1922.)

Subdural hematoma may be the same condition although it is described as such by name. There is, however, frequently a history of trauma, although it may be trivial. (See Leahy: Subdural Hemorrhages, J. A. M. A. 103: 897, Sept. 22, 1934, and Munro: New England J. Med. 227: No. 3, July 16, 1942.)

Spontaneous arachnoid hemorrhage not caused by trauma is evidently of the same general nature. Some cases may be due to purpura. The symptoms are headache (75 per cent of all cases), unconsciousness (58 per cent), drowsiness and sleepiness (25 per cent), pain and stiffness of the neck (25 per cent), vomiting (17 per cent). The deep reflexes are hyperactive. Choked discs occurred in 33 per cent of cases, positive Kernig in 17 per cent, temperature above 100° F. in 42 per cent. Bloody spinal fluid is the rule. (Dowling: Am. J. M. Sc. 175: 469, April, 1933.)

Arachnoiditis is somewhat different in that the pathology consists of small collections of cystic structures held by adhesions in the arachnoid spaces. It also most frequently is located in the spinal meninges and produces symptoms of radicular or rootlet pain in most instances. (See Blumstein and Baker: Ann. Int. Med. 18: No. 5, May, 1943.)

C. Coma

The causes of coma are adequately discussed on p. 145.

D. Delirium

The causes of delirium are adequately discussed on p. 153.

Part 4

LABORATORY AND SPECIAL PROCEDURES

Chapter 16

EXAMINATION OF THE URINE

On a shelf over the bed of each patient in Guy's Hospital, in the days when I visited their wards, stood a conical glass with a specimen of the incumbent's urine. The physician could not miss it, and had to observe at least its gross clinical properties. That is clinical medicine.*

The clinicians of my early years of practice certainly knew and used many a tricky method of examination of the urine. That was about all their clinical laboratory examination consisted of. The importance of the urine examination has shrunk and shrunk, until there is a possibility that the clinician of today will not ask for it at all. Which would be too bad. Every diagnosis should include an examination *made by the examiner himself*.

The life insurance companies with their sure sense of realities insist upon knowing whether the specimen is clear, the specific gravity, the reaction, and whether there is albumin or sugar. On special cases they ask for a microscopic examination of a centrifuged specimen. That certainly is all that is necessary for any routine diagnosis.

More dependence is put nowadays on blood analysis for retention products as a guide to the state of renal excretion. But the urine is still, as it were, a more solid structure to build on. You do the tests yourself or should, as a good clinician, and you have the evidence of what your own hands and eyes accumulated. With blood chemistry you have to depend on the color judgment of a technician. And in functional tests that indicate an anatomic background, nothing is better than the study of the twenty-four-hour specimen, the comparison of day and night volumes, and the specific gravities as revealed in the concentration and Mosenthal tests.

The urine is the result of first the filtration in the kidney glomeruli of the plasma fluid from the blood; this fluid contains all substances present in the blood except protein and cells. The fluid proceeds down the tubule; the tubule cells resorb water and such solid elements in solution as glucose, electrolytes, and waste products selectively according to each individual threshold value. Some water (1,200 to 1,500 c.c. per 24 hours) and some waste products are rejected by the kidneys, and this mixture passes on to the bladder, taking cells, debris, and other products, such as gravel if present in the pelvis, ureters, bladder and urethra, as it emerges as urine.

The gross examination of the urine often gives a great deal of information. Many an obscure case of fever in an infant or child has been cleared

*See opening paragraph of chapter on sputum.

up by taking the trouble (and because it is trouble in infants it is so often neglected) to obtain a urine specimen which on centrifugation shows a heavy sediment of pus cells. Gross blood in the urine suggests tuberculosis, stone, tumor of the kidney, or idiopathic hematuria, which, I am afraid, in spite of some skepticism, exists.

Cloudy urine is usually of no significance. Freshly voided urine should be clear. The exceptions are:

1. An alkaline urine cloudy because of phosphates.
2. Pus or blood cells.

Upon standing, urine may become cloudy because of:

1. Bacterial decomposition.
2. Precipitation of alkaline salts (phosphates).
3. Precipitation of urates in acid urine.
4. On cooling a faint cloud of mucus, leucocytes, and epithelial cells may become visible.

The color of urine varies with the concentration. The chief normal pigment is urochrome, a product of *endogenous* metabolism, possibly derived from muscle. It is excreted in constant quantities regardless of the kind of food intake.

Urobilin, a yellow pigment, is normally present in traces. Under conditions of increased blood destruction, hemolytic icterus, or liver damage, increased amounts of urobilin appear in the urine.

Other bile pigments, *bilirubin* and *biliverdin*, are present in obstructive jaundice.

Hemoglobin, blood, and *porphyrine* give a reddish color. Urine acid may be mistaken for blood on gross examination.

Hemoglobinuria is classified into toxic or paroxysmal; chemical poisons, such as carbolic acid, carbon monoxide, snake venom, and febrile states, especially malaria (blackwater fever) and scarlet fever, are causes of toxic hemoglobinuria.

Paroxysmal hemoglobinuria is a rare disease, the commonest cause being late syphilis, either congenital or acquired. Cold also operates; in sensitive persons an attack may be precipitated by immersion of the hands or feet in cold water. The attack consists of malaise, pain over the kidney region, a sensation of chilliness, chill, and transitory fever. The Donath and Landsteiner reaction on the blood shows hemolysis when the blood is chilled to 5° C. and then warmed to 37° C. Normal blood so treated shows no hemolysis.

Black urine is caused by melanin and homogentisic acid (alkaptonuria).

Various drugs produce characteristic colors in the urine.

The amount of urine excreted in 24 hours is about 1,500 c.c. but varies, of course, with fluid intake, sweating, vomiting, diarrhea, etc. Fever usually produces an oliguria. Diuretics operate by intubation of tubular resorption. Glomerular filtration, which excretes nitrogenous waste, is not affected by diuretics.

The polyuria of diabetes mellitus is easily explained by increased water intake, to allay the thirst. Diabetes insipidus produces the most enormous water intake of any clinical condition, and may result in the daily excretion of three to ten liters; it is associated with pituitary disturbance.

The polyuria of contracted kidney, or of any nephritis which destroys a number of glomeruli, is due probably to decreased tubular resorption. The glomerular filtration is actually diminished.

Nocturia is a most important symptom of nephritis. It may be associated with and increased by prostatic hypertrophy. A comparative measurement of the day and night urine is one of the best barometers of renal function. The *night volume should be one-third to one-fourth the day volume*. When the urine excretion is distributed equally or nearly equally over day and night periods, it means the kidney needs a twenty-four-hour compensation period to perform its function. Even more valuable is the measurement of the specific gravity during the twenty-four-hour interval in a series of specimens, collected every two hours (the Mosenthal and concentration diuresis tests; see Kidney Function).

Reaction of the urine is normally acid, although, of course, this depends upon the diet, the ingestion of alkaline drugs, and other factors. Proteins break down into sulfuric and phosphoric acids which appear in the urine. In fasting, protein catabolism from the body muscles produce the same condition. The acid urine of diabetes is due to acetone bodies. In nephritis there is a decidedly acid urine because the excess acid is not so completely neutralized by ammonia as in health.

Alkaline urine results from a fruit and vegetable diet. In cystitis and pyelitis the urine is strongly alkaline because of the action of bacteria on urea to form ammonia. Urine allowed to stand without a preservative becomes alkaline for the same reason—formation of ammonia from urea by bacteria.

Specific Gravity.—Single examinations for specific gravity have no significance—only the specific gravity of a twenty-four-hour specimen or the determination of a series of specimens collected under controlled conditions, as in the Mosenthal test. The standard for normal specific gravity is 1.020. The life insurance companies demand such a specimen because they wish to be sure that the applicant either can concentrate to that degree or that a high specific gravity does not indicate sugar.

Albumin.—What or why albuminuria is still remains a mystery. We assume that it is derived from the blood plasma due to increased permeability of the glomerular filter, but that is pure assumption.

It may be determined by the heat and acetic acid test, the nitric acid, or the nitric acid-magnesium sulfate test. There is much to be said for the view that the nitric acid test is best because it is the coarsest. When properly done, it is also most readily interpreted without errors. The urine should be superimposed on the nitric acid by means of a medicine dropper with a rubber bulb. This gives a clear line of demarcation. Modern technicians, using a long pipette with the thumb over the upper end, are unsuccessful about a third of the time. If the heat test is used, the test tube should be held against a dark

background with a cross light. *There is no important sign so carelessly and inaccurately reported as the presence or absence of albumin.* The proper way to do it is to do it yourself.

With delicate methods albumin can be found in any urine. In some hospital laboratories urine could contain as much albumin as an egg without being suspected.

The causes of albuminuria are:

Functional and transitory—too numerous to estimate.

Febrile state—65 per cent.

Pyelitis (or other cause of pus in the urine)—10 to 11.5 per cent.

Congestive heart failure—9 to 11.5 per cent.

Nephritis (chronic interstitial or glomerular)—4.5 to 6.5 per cent.

Acute nephritis (scarlatina, etc., including eclampsia, kidney of pregnancy, etc.)—3 to 2 per cent.

Hematuria (not nephritic)—2.5 to 1.5 per cent.

Orthostatic albuminuria—1.0 to 0.5 per cent.

Nephrosis—0.5 to 0.1 per cent.

If one includes the transitory albuminuria of high blood pressure under nephritis, the percentages under that heading go up. The table was made up of cases in which the albuminuria was a factor in the whole clinical picture.

In any given case of cardio-renal-arterial syndrome the question whether the albuminuria is due to nephritis or congestive heart failure is debatable. Both factors enter into most cases. In chronic nephritis without cardiac failure there is usually only a trace of albumin. When a prognostic mood occurs we should always remember Osler's title—"On the advantages of finding a trace of albumin and a few casts in the urine of men over fifty."

Acute nephritis is still, as it was in the days of Cabot, a stumbling block. The problem is: given a patient with scarlet fever, or a pregnant woman with albuminuria, is there nephritis? Determining factors are the presence of blood and casts in the urine in the case of scarlet fever; edema, elevated blood pressure and pathologic eye grounds in the case of pregnancy, and changed blood chemistry in both cases. But these are late developments. The presence of albumin is always a warning signal to pay especial attention to the onset of these signs (especially in pregnancy where therapeutic abortion may have to be under consideration). The presence of albuminuria after mercury poisoning is always of grave significance.

Orthostatic albuminuria is an interesting phenomenon, and in certain groups of individuals (young people, athletes, lordotic types) it may show a much higher relative percentage of incidence than my table indicates. Nor is orthostatic albuminuria always orthostatic; it does not always disappear on assuming the recumbent position. It is by no means always associated with lordosis, negating the value of the designation once used, "lordotic albuminuria." The most important deduction that can be made from it is that it is not of serious prognosis. I once made a list of all such cases, discovered by me on routine life insurance examination. I requested the patients to return for reexamination and some of them did for years. The significant point about

the group was that they were apparently healthy, active individuals, unaware of the albuminuria, and suffering from no symptoms of it. They remained so during the period of re-examination with two exceptions: one developed Hodgkin's disease and the other pulmonary tuberculosis. Some of them complained of undue fatigue; one, a semiprofessional baseball player, had to give up playing, but before he applied for insurance.

Patients with orthostatic albuminuria certainly do not have nephritis; there is low blood pressure and negative blood chemistry. The amount of albumin is always great. It probably has some significance, but what, I do not know. A full, nourishing diet and iron for the anemia that is often present sometimes clear it up.

Quantitative estimates of albumin are of no clinical significance.

Bence-Jones proteinuria is a very rare condition that should be specifically looked for in multiple myeloma, hyperparathyroidism, bone tumors. It is sometimes present in leucemia and empyema. There is a high serum globulin. It is a constituent of bone marrow, manufactured by leucocytes.

Sugar in the urine is due to diabetes in over 99 per cent of instances. The sugar present in alimentary glycosuria, lactose during lactation, and pentose from excessive fruit consumption may have to be differentiated, as all reduce copper in the test solutions (Fehling, Benedict) ordinarily used. Renal diabetes assumes a low threshold for glucose in the kidney and is associated with blood sugar levels, normal or only slightly elevated. Hyperthyroidism and pituitary disease sometimes produce glycosuria. It is doubtful whether intracranial injuries to the floor of the fourth ventricle do so, except in textbooks.

In diabetes the quantitative determination of the amount of glucose in a twenty-four-hour specimen, collected while the patient is on a fixed carbohydrate intake, is the necessary prerequisite for treatment. This is not emphasized sufficiently in the literature, and the student is left with the idea that the blood sugar level is all important. The blood sugar level and tolerance test simply confirm the diagnosis that real diabetes mellitus is present and aid in determining the renal threshold. Only by the quantitative urine test can the patient's glucose tolerance be determined. If, on an intake of 100 grams of carbohydrate, the twenty-four-hour specimen shows 2 per cent glucose in 1,600 c.c. of urine, the tolerance is 68 grams, and a diet can be constructed on that basis.

The glucose tolerance test is not accurate when urine is used, because the factor of renal threshold is not determined. When the blood sugar level rises above 160 mg. per 100 c.c., sugar appears in the urine. With a normal metabolism this level is not reached, even with the ingestion of large amounts of carbohydrate.

MICROSCOPIC EXAMINATION OF THE URINE.—*Crystals* of whatever kind are of no clinical significance.

Red blood cells are normally present in the urine, but in such small quantities (67,000 in a 12-hour specimen—Addis) that one is seen only occasionally in a low power field. If in excess, but not in sufficient numbers to be observed

grossly, they may have some significance in indicating stone in the urinary tract, tuberculosis, hypernephroma or other tumor of the kidney or bladder, renal infarction, or acute nephritis. In women the occurrence of bleeding from the uterus or vagina should not be considered.

Pus cells in any quantity indicate a suppurative process in the urinary tract. Especially important, as noted above, is the examination of infants' urine for pus cells.

Epithelial cells are desquamated and appear in the urine under the same circumstances that cause pus and blood cells. The identification of these cells to determine what parts of the tract they come from is a relic of the past.

Casts are passed normally about 1,000 per 12-hour specimen (Addis). In larger quantities they can be observed in a centrifuged specimen several or many to a field. They have about the same significance as albumin, although when persistent, they probably indicate actual renal damage more emphatically than does albumin. Differentiation of hyaline, granular, epithelial, hemorrhagic, and other casts is not rewarded in the field of differential diagnosis. The "flat casts of renal failure" described by Addis cannot be relied upon to furnish accurate deductions, largely because no two persons can agree on whether a given cast is of that variety.

URINE: NORMAL VALUES*

Volume	900-1,200 c.c.--24 hours
Specific gravity	1.015-1.025
Albumin	0-30 mg.--12 hours
Casts	0-5,000--12 hours
Erythrocytes	0-1,000,000--12 hours

*This table and following tables are taken from Smith, Weiss, Lillie, Konzelman and Gault: *Cardiovascular Renal Disease*, 1940.

URINE: ERYTHROCYTES

N-1	400,000,000
N-2	30,000,000
N-3	26,000,000
Nephrosis	200,000-800,000
Nephrosclerosis	
Senile	0 to 2,000,000
Benign	0 to 2,000,000
Malignant	1,000,000-3,000,000

URINE

	VOL.	SP. GR.	ALB.	CASTS
N-1	Anuria	1.022-1.032	100-600	40,000-50,000
	600-100			H & G*
N-2	500-1,200	1.015-1.030	6,000	2,000,000 H & G
N-3	1,000-3,000	1.002-1.015	3,000	400,000 H & G
Nephrosis	300-400	1.040	5,000-20,000	400,000-600,000 H & G
Nephrosclerosis				
Senile	900-1,500	1.015-1.025	0-40	0-25,000
Benign	1,000-2,000	1.015-1.025	0-500	0-30,000
Malignant	1,000-2,000	1.010-1.020	600-1,000	40,000-50,000

*Hyaline and granular.

BLOOD: NORMAL VALUES

Nonprotein nitrogen	25.35 mg per 100 c.c.
Urea nitrogen	8.18 mg per 100 c.c.
Creatine	1.2 mg. per 100 c.c.
Serum albumin	3.4-4.9 Gm. per 100 c.c.
Serum globulin	2.3-2.9 Gm. per 100 c.c.
Cholesterol	150-200 mg. per 100 c.c.

RENAL FUNCTION TESTS: NORMAL VALUES

P.S.P. (I.V.)	55% in 2 hours
Concentration	Max. 1,025 Variables

BLOOD

	N.P.N.	UREA N.	CREAT.
N-1*	35-200	20-100	2-5
N-2†	30-80	18-50	2-6
N-3‡	100-300	60-200	5-25
Nephrosis—	Normal values		
Nephrosclerosis			
Senile	25-35	8-25	1-3
Benign	25-35	8-25	1-3
Malignant	100-300	60-200	10-15

*N-1 = Glomerulonephritis—initial stage.

†N-2 = Glomerulonephritis—second stage (nephritic).

‡N-3 = Glomerulonephritis—terminal stage.

RENAL FUNCTION TESTS

	P.S.P.	CONCENTRATION
N-1*	55—15%	Max. 1,025—HF
N-2†	55—35%	Max. 1,025—HF
N-3‡	35—10%	Max. 1,010—LF
Nephrosis	Normal	Max. 1,030—HF
Nephrosclerosis		
Senile	Normal	Normal
Benign	55%	1,015-1,020 F
Malignant	35—10%	1,010 F

*N-1 = Glomerulonephritis—initial stage.

†N-2 = Glomerulonephritis—second stage (nephritic).

‡N-3 = Glomerulonephritis—terminal stage.

HF = high fixation; LF = less fixation; F = fixation.

BLOOD: SERUM ALBUMIN

	SERUM ALBUMIN	SERUM GLOBULIN	CHOLESTEROL
N-1	1.6-4.6	1.3-3.1	Normal
N-2	1.6-4.6	1.3-3.1	Normal
N-3	2.4-3.9	2.3-3.0	Normal
Nephrosis	6.0-26	2.2-3.6	500-1,000
Nephrosclerosis			
Senile	3.4-4.9	2.3-2.9	Normal
Benign	3.4-4.9	2.3-2.9	Normal
Malignant	3.2-4.4	1.5-2.5	Normal

Chapter 17

EXAMINATION OF THE BLOOD

Normal Standard Values

Red blood cells per cubic millimeter	5,000,000
White blood cells per cubic millimeter	5,000
Proportion of white cells morphologically:	
Polymorphonuclears	65-75%
Lymphocytes	20-35% (higher in infants)
Eosinophiles	1-4%
Basophiles	0.25-0.50%
Monocytes	4-10%

Platelets per cubic millimeter—200,000-500,000 (or 1 to every 25 R.B.C.)

Hemoglobin—100 per cent is 15.34 grams in 100 c.c. of blood with a cell count of 5,000,000

Volume Index (mean cell volume relative to normal).

Color Index (mean cell hemoglobin) hemoglobin in grams per 100 c.c. by the number of cells per c. mm. compared to normal $\frac{15.4}{5,000,000} \times 100 = 0.9$ to 1.10.

Saturation Index (mean cell saturation index)—1

Blood Volume—5 liters—2,326 c.c. packed cells (male); 1,482 c.c. (female).

Blood Sedimentation Rate.—

Men, 0 to 15 mm.; women, 0 to 20 mm. (Westgren method).

Men, 0 to 6.5 mm.; women, 0 to 15 mm. (Wintrobe method).

Men, 0 to 8 mm.; women, 0 to 10 mm. (Cutler method).

Children: less than 10 (Westgren method).

3 to 13 mm. (av. 9), (Wintrobe method).

Coagulation Time.—By test tube method: average 7 minutes, variation of 5 to 15 minutes. By micromethods: 1-5 minutes.

Bleeding Time.—1 to 6 minutes.

Prothrombin.—Normal plasma on recalcification in the presence of an excess of thromboplastic substance will clot in 12 to 20 seconds. With a decrease in prothrombin this is delayed.

Fragility.—Normally red cells are suspended in a medium that is isotonic at 0.85 per cent. When this medium is decreased in strength, the cells will not hemolyze until the content is about 0.44 per cent. Such cells have a "normal fragility." If they hemolyze above this point, it indicates some degree of fragility.

The hematopoietic system* includes the following:

1. Bone marrow which forms (1) neutrophilic, basophilic, and eosinophilic leucocytes, (2) red cells, and (3) platelets, and (4) synthesizes hemoglobin.

*Based on Haden's classification (*Principles of Hematology*, Lea & Febiger, 1939).

2. Spleen which (1) forms monocytes and lymphocytes, (2) acts as a reservoir for red cells, (3) destroys red cells which have lived their normal life span or are abnormal, and (4) disintegrates hemoglobin.

3. Lymph nodes which form lymphocytes.

4. Stomach mucosa which forms the erythrocyte-maturing factor.

5. Liver which (1) stores the erythrocyte-maturing factor, (2) forms fibrinogen and probably other clotting elements, (3) excretes the end product of hemoglobin destruction, bilirubin.

6. Reticulo-endothelial system which is widely distributed in the body in blood vessel walls and is particularly concentrated in the spleen and bone marrow. It (1) forms monocytes, (2) destroys red blood cells, (3) converts hemoglobin into iron and bilirubin in the spleen, (4) stores iron in the marrow, (5) synthesizes hemoglobin in the marrow.

7. Circulating blood.

The interpretation of laboratory reports on the blood depends upon the conception of the blood as a tissue which originates from cells in the bone marrow, the lymphatics, and reticulo-endothelial system. The cells when mature enter the blood stream. They live there a varying length of time. When senile (or fragile) the red blood cells are destroyed in the spleen, the white cells on the surfaces of the body, such as the mucous membrane of the digestive tract, the kidney epithelium, etc. The origin of the plasma and the elements which cause coagulation—(except the platelets) is probably the liver.

This process is kept in very delicate balance so that in health the number of cells produced and destroyed is so evenly equilibrated that the number of red cells and the number of white cells per cubic measure in the circulating blood is the same hour by hour.

Various agencies can, of course, upset the balance. Any agency which depresses the bone marrow will cause an anemia. The destructive action of the spleen may be increased.

The marrow is conditioned to its activity by the action of a substance (erythrocyte-maturing factor) produced in the gastric mucosa, and stored in the liver. When, as in pernicious (Addisonian) anemia, the gastric mucosa is atrophied and this substance is not produced, the marrow degenerates and produces only a small proportion of its normal output of red blood cells.

Interpretation of Abnormal Cells in the Blood Smear

Formation of blood cells in different parts of the body—bone marrow, lymph nodes, spleen—goes on in the adult, as in fetal life, by the development of mature cells from primitive, undifferentiated or mother cells. The clinician need not subscribe to any one of the various theories of the nature or origin of a single type or several types of mother cells. He must have a conception, however, of the development of the different cells which can be seen in normal smears because, for one reason or another, immature cells of one series or another may be extruded into the blood stream.

The primitive red cell is called the megaloblast. It is a large nucleated cell. As it matures, it gets smaller, retains its nucleus for a time (normo-

blast), then forms a reticulum (reticuloocyte), and finally becomes the normocyte or erythrocyte—a small biconcave disc, about 7.7 microns in diameter. Reticuloocytes appear normally in circulating blood in the proportion of about 0.5 to 1.0 per cent of total red cells. Their increase indicates the beginning of regeneration—normal active development. When liver therapy is used in pernicious anemia, the appearance of reticuloocytes, which may amount to 50 per cent or more, indicates that the marrow is returning to normal function.

The appearance of nucleated red cells in the circulating blood stream is an indication of hyperactivity on the part of the bone marrow. This hyperactivity is a compensatory process following more or less grave destruction of the marrow or the absence of the erythrocyte-maturing factor, as in pernicious anemia. Normoblasts may be found in any of the severe anemias, but not in the aplastic anemias where the marrow makes no response. At times in pernicious anemia they appear in large quantities, indicating a blood crisis and heralding the onset of a period of regeneration, but again it may mean a falling red count. In the secondary anemias the appearance of normoblasts in large quantities is more likely to mean beginning regeneration. The megalo-blast, being less mature than the normoblast, is of more serious import in the blood stream; it occurs in pernicious anemia and also in myelogenous leucemia.

Macrocytes (large red cells), microcytes (small red cells), anisocytosis (variation in the size of red cells), and poikilocytes (abnormally shaped red cells) indicate various kinds of deficient marrow activity. The macrocyte is the typical cell of pernicious anemia, though it also appears in the anemia of pellagra, liver damage, sprue, and pregnancy. Microcytes occur in secondary anemias due to iron deficiency, malnutrition, pregnancy, parasitic infestations, and infections.

The red cells may stain deeper than normal (hyperchromia) due to increased hemoglobin content, or lighter than normal (hypochromia) due to decreased hemoglobin (as in chlorosis, primary microcytic hypochromic anemia, and iron deficiency anemias). The presence of granules (Cabot ring bodies, Howell-Jolly bodies) which stain somewhat different from the rest of the red blood cell protoplasm is of little significance, though they are usually found in the anemias.

Target cells are red cells with a thin, punched out center. They are characteristic of a familial anemia often found in Mediterranean countries and called Mediterranean anemia.

Sickle cells are red cells of a totally unique sickle shape. They are found in an hereditary anemia that occurs in this country, mostly in the colored race. It is a dominant Mendelian character. There are often changes in the bones of the calvarium, consisting of trabeculation and spiculation, which can be seen on the x-ray plate.

The White Cells.—The neutrophile, basophile, and eosinophile polymorphonuclear leucocytes develop from a primitive cell in the bone marrow called a myeloblast. Juvenile intermediate forms are the myelocytes with large round or oval nucleus. Their appearance in the circulating blood in any quan-

tity occurs almost exclusively in myelogenous leucemia. Sometimes a few appear in the course of a severe anemia and in children with a severe leucocytosis.

Leucocytosis.—The normal number of white cells is usually said to be around 5,000 to 7,500, but this is subject to physiologic variations. In the newborn the number may be as high as 12,000 or even 20,000; by the end of the first week of life it has settled to 10,000, and during late pregnancy and the onset of labor it may rise to 20,000.

The question arises: aside from these physiologic variations, what count should be considered as significant of a pathologic leucocytosis? My experience indicates that counts up to 10,000 can easily be ascribed to technical laboratory variation. After that up to 20,000, the significance depends on the clinical condition.

Counts over 20,000, if confirmed, take on a value of their own, irrespective of the rest of the clinical picture.

Neutrophile polymorphonuclear leucocytes are increased in the circulating blood when an infection produces a tissue need for more leucocytes. This is the common infectious leucocytosis. We know little about the substances which stimulate the marrow to either normal or increased production of leucocytes, but we assume that certain kinds of infection, particularly staphylococcic and pneumococcic—do this. Noninfectious leucocytosis also occurs after hemorrhage (note ectopic pregnancy), vascular thrombosis (especially note the leucocytosis of coronary thrombosis), cerebral hemorrhage, during gout, uremia, sometimes in malignant disease, intestinal obstruction, poisoning by drugs, and as a result of skin irritants, such as turpentine. (See Pepper, O. H. P.: Causes of Leucocytosis, *M. Clin. North America*.) Silent areas of abscess formation, brain abscess, and empyema of the gall bladder are frequently present without leucocytosis.

Arneth's shift to the left; the Schilling count; Cooke and Ponder classification; Pons and Krumbhaar classification; Farley, St. Clair, and Reisinger classification—all of these are attempts to evaluate the severity of infection and the nature of the marrow response to the production of leucocytes by classifying the circulating leucocytes on the basis of the morphology of the nucleus, i.e., whether the nucleus has one, two, three, four, or five lobes, etc. In my experience the practical value of this information, even were it based on dependable premises, is very small.

Toxic degeneration of the leucocytes consists in the appearance during a leucocytosis, of a large number of leucocytes with nonfilamented nuclei, and with basophilic granules in the cytoplasm, along with a great decrease in the oxidase-staining granules in the cytoplasm. This is supposed to show not only an infection which produces leucocytosis, but also one with a toxemia that affects the marrow adversely, so that it cannot mature its cells normally.

Eosinophiles are increased in parasitic infestations (especially notable in trichinosis) and allergic reactions (asthma, hay fever, urticaria).

Basophiles are of no clinical significance yet discovered.

Leucopenia, Granulopenia.—Reduction of leucocytes in the circulating blood may be due to (1) aplasia or hypoplasia of the bone marrow, from (a) infections (measles) which reduce rather than stimulate marrow activity to leucocytosis, (b) radiant energy, and (c) some chemicals (benzol); (2) severe depression of marrow activity with selective interference with maturation, as by drugs, especially amidopyrine; (3) splenic disease (Banti's); (4) mechanical interference with the escape of whole cells from the marrow, as in myeloma and pernicious anemia.

Lymphocytosis.—Lymphocytes do not share, to any considerable extent, in the increase of granulocytes in leucocytosis from staphylococcic and pneumococcic infections. They are increased in whooping cough (even up to 100,000). Infectious mononucleosis is a not very rare disease of unknown etiology, characterized by fever, enlargement of the lymph nodes, and a lymphocytosis (total leucocyte count reaches 20,000). Its resemblance to lymphatic leucemia often leads to grievous errors of diagnosis. Lymphatic leucemia is the third cause of increase of lymphocytes in the blood.

Monocytosis is rare, but there is a form of monocytic (sometimes called "histiocytic") leucemia.

Color index and volume index are very valuable determinations. The final diagnosis of the kind of a primary anemia present, whether Addisonian (hyperchromic macrocytic) or hypochromic microcytic, with different therapeutic implications (liver in the one case, iron in the other) involved, may depend upon this determination.

Color index indicates the erythrocyte hemoglobin relative to normal or mean cell hemoglobin content. Dr. Richard Cabot used to advise that in a routine physical examination all that is necessary so far as blood examination is concerned is to estimate the hemoglobin on a Tallquist color scale (but that this must be done in every case). I still find this sound advice, but, of course, methods of determination of hemoglobin have greatly improved since that time. Now we can determine the number of grams of hemoglobin per 100 c.c. of blood, which is always normally close enough to 15.4 that the figure is used arbitrarily.

The calculation is made:

Number of grams of hemoglobin per 100 c.c.	15.4
Normal number of grams of hemoglobin per 100 c.c.	15.4
Number of red cells found per cubic centimeter	5,000,000
Normal number of red cells found per cubic centimeter	5,000,000

A sample calculation for a patient with pernicious anemia would be:

$$\frac{\frac{6.16}{15.4}}{\frac{1,500,000}{5,000,000}} = 1.33$$

Volume index.—Volume of mean cell relative to normal.

$$\frac{\text{Number of cubic centimeters of packed cells per 100 c.c.}}{\text{Normal number of cubic centimeters of packed cells per 100 c.c.}}$$

$$\frac{\text{Number of red cells found}}{\text{Normal number of red cells}}$$

Sample calculation:

$$\begin{array}{r} 45 \\ \hline 45 \\ \hline 5,000,000 \\ \hline 5,000,000 \end{array} = 1.00$$

In anemia:

$$\begin{array}{r} 18 \\ \hline 45 \\ \hline 1,500,000 \\ \hline 5,000,000 \end{array} = 1.33$$

(Sample calculations from Haden)

Saturation index is the amount of hemoglobin per unit volume of cells relative to normal.

$$\frac{\text{Number of grams of hemoglobin found in 100 c.c.}}{\text{Normal number of grams of hemoglobin per 100 c.c.}}$$

$$\frac{\text{Number of cubic centimeters of packed cells found per 100 c.c.}}{\text{Normal number of cubic centimeters of packed cells per 100 c.c.}}$$

Sample calculation:

$$\begin{array}{r} 15.4 \\ \hline 15.4 \\ \hline 45 \\ \hline 45 \end{array} = 1.00$$

The normal figure is 1.00 with a range of 0.85 to 1.15, and figures under 0.80 or over 1.20 should be regarded as indicating a pathologic condition. It is not of much significance in solving diagnostic puzzles.

Chapter 18

BLOOD CHEMISTRY

Normal Standard Values

Nonprotein Nitrogen—25 to 35 mg. per 100 c.c. of blood.

Urea-Nitrogen—12 to 15 mg. per 100 c.c. of blood.

Uric Acid—1 to 3 mg. per 100 c.c. of blood. (Normal values depend on method used—see below.)

Creatinine—1 to 2 mg. per 100 c.c. of blood.

Blood Sugar—80 to 120 mg. per 100 c.c. of blood.

Glucose Tolerance—Return to fasting level within 2 hours after ingestion of 100 Gm. of glucose.

Cholesterol—150 to 200 mg. per 100 c.c. of blood.

Amylase—80 to 150 mg. per 100 c.c. of blood.

Iodine—1.5 to 12.8 micrograms ($\frac{1}{1,000}$ of a milligram) per 100 c.c. blood.

Calcium—9 to 11.5 mg. per 100 c.c. of blood.

Phosphorus—2 to 5 mg. per 100 c.c. of blood (higher in children).

Phosphatase—1.5 to 4 Bodansky units per 100 c.c. of blood. (Jenner-Kay and King units are approximately equal to 2 Bodansky units.)

Carbon Dioxide Combining Power of the Blood Plasma—55 to 80 per cent.

Sodium—335 mg. per 100 c.c. of blood.

Potassium—420 mg. per 100 c.c. of red blood cells and 20 mg. per 100 c.c. of blood serum.

Proteins—6 to 8 grams per 100 c.c. of blood. Serum albumin 4.5 to 5.5 per cent; serum globulin 1.5 to 3.0 per cent.

Chlorides—570 to 600 mg. per 100 c.c. of plasma; whole blood 450 to 500 mg. per 100 c.c.

The chemical analysis of the blood for various metabolites has now been developed to a high state of accuracy and dependability, and the results have become thoroughly assimilated into clinical experience. In no other department of laboratory diagnosis, however, is the intelligent direction of the attending physician more necessary, if the information is to mean anything.

Dr. Reed Rockwood, of Baltimore, warned us many years ago (*J. A. M. A.* 91: No. 3, July 21, 1928) against ordering a "routine blood chemistry." To the laboratory this is a term utterly devoid of meaning. It suggests, in fact, that the clinician knows nothing of the indications for chemical analysis, and in a difficult case begins snatching at diagnostic straws. Practically every one of the tests listed above is indicated only in the presence of the possibility of one or two definite conditions, and to ask for them in a general diagnostic puzzle is generally a waste of time.

Dr. Rockwood also gave some hints as to the indications for chemical tests of the blood and their interpretation as follows:

1. Never ask for both nonprotein nitrogen and urea tests in the same patient. What is meant here is that the urea clearance test is a more delicate test of renal function than the total nonprotein nitrogen test. Both are tests for renal function. As the renal tissue is progressively destroyed in nephritis, the earliest disturbance is an inability of the kidney to concentrate the solid constituents of the urine. The failure appears first in urea excretion. However, certain modifications (see below) negate, to a considerable extent, this first statement of Dr. Rockwood, although it still indicates a valuable principle.

2. Except in emergency, never ask for a nonprotein nitrogen determination unless a phenolsulphonphthalein test has first been done.

The phenolsulfonphthalein test for renal function may not always show every degree of renal failure (see discussion under functional tests, p. 650), but in general it is a waste of time to determine nonprotein nitrogen if it is normal. The clinician should remember that the determination of nonprotein nitrogen is the least sensitive of all the tests for renal function.

3. Creatinine is not likely to be increased in the blood unless the nonprotein nitrogen is over 60 mg. If a report to the contrary is submitted, it should be suspected.

4. Order determination of uric acid only in cases of gout or suspected gout.

5. Order blood sugar determinations only in cases of diabetes or suspected diabetes or hypoglycemia.

6. Ask for a test for carbon dioxide combining power of the blood plasma in:

- (a) Diabetic patients with diacetic acid in the urine.
- (b) Uremic patients with nitrogen retention and dyspnea.
- (c) Patients who are receiving large doses of alkali and who are showing toxic symptoms.
- (d) Conditions associated with disturbed motility of the gastrointestinal tract.
- (e) Tetany of all types.

"If I were limited to one chemical test on blood in the practice of medicine I would choose this (the carbon dioxide combining power of the blood plasma), as I believe it would give me more important information where it is most needed in sick patients than any other."—(Rockwood.)

7. Order chloride, nonprotein nitrogen, and carbon dioxide combining power determinations in all cases of gastrointestinal motility with marked toxemia.

8. Ask for serum bilirubin or icterus index tests in cases of jaundice, but do not pay much attention to the borderline values.

9. Ask for blood calcium determinations in cases of tetany of unknown origin.

10. Order inorganic phosphorus tests only in cases of rickets and infantile tetany.

"The total blood volume in an average adult is about 5 liters—an amount that will half fill an ordinary household bucket. In this half bucket of blood there are dissolved a teaspoonful of sugar, a tablespoonful of sodium chloride and 12 Gm. or about a tablespoonful of sodium bicarbonate. The entire circulating blood contains about 30 grains (2 Gm.) of nonprotein nitrogen or the equivalent in weight of six five-grain (0.3 Gm.) tablets. From 1 to 3 grains (0.065 to 0.2 Gm.) of uric acid and creatinine are present, and about one hundredth grain (0.6 mg.) of iodine. From one teaspoonful to one tablespoonful of fat is present, and there is also about a teaspoonful of cholesterol, or the amount that could be extracted from two dozen egg yolks."—(Rockwood.)

Nonprotein Nitrogen.—The nonprotein nitrogen of the blood consists of urea, uric acid, creatinine, creatine, amino acids, and other nitrogenous compounds called "undetermined nitrogen." They are the products of protein catabolism and are normally excreted largely by the kidney, a small amount being excreted by the skin and in the feces. The amount of these substances in the blood depends upon the functional ability of the kidney to concentrate and excrete them, upon the amount of protein intake, and upon the extent of protein catabolism.

Amounts above 40 mg. per 100 c.c. of blood must be regarded as beyond the limits of normal. In uremia the nonprotein nitrogen may rise to 300 mg. per 100 c.c.

Nitrogen retention which occurs in functional impairment of the kidney may also occur in dehydration from any cause and in increased protein catabolism.

In experimental work, the nonprotein nitrogen does not rise until four-fifths of the kidney substance is destroyed. Clinically, the greatest increases are in acute glomerulonephritis and in the last stages of chronic nephritis and nephrosclerosis. It is, therefore, not an early or delicate test of kidney impairment. In nephrosis or the nephrotic syndrome when the renal damage is mostly in the tubules, even with albuminuria and edema, there is little change in the nonprotein nitrogen of the blood. In prostatic hypertrophy there is usually a rise, and, probably more than any other place in clinical medicine, the determination of nonprotein nitrogen is of significance in coming to a judgment of the operative risk involved in prostatectomy. In dehydration from vomiting, diarrhea, etc., there is a rise. Urotropin intravenously for some reason raises the nonprotein nitrogen.

Urea.—Urea is the chief constituent of nonprotein nitrogen. In the deamination of the amino acids in protein utilization, ammonia is formed, and in the liver urea is derived from this ammonia. The normal range is from 12 to 15 mg. per 100 c.c. of blood. Normally, urea makes up about 50 per cent of nonprotein nitrogen, but in pathologic states this proportion does not hold because urea is retained to a greater degree than uric acid or creatinine. Urea retention is also measured by the urea clearance test, the generally accepted normal value being about 75 c.c.

Uric acid is derived both from ingested protein food and from the breakdown of body cells. Normal values differ somewhat, depending on the technique used. By the old Folin method 1 to 3 mg. was generally accepted as

normal, and 3.5 to 5.7 in gout, but by the Folin modification normals are from 2.5 to 5.5 and in gout 5.1 to 10.7 per cent. In an acute attack of gout, the levels may go to 15 or more.

Creatinine is the anhydride of creatine and is formed from it as the end product of its metabolism. Its concentration in the blood is very constant and is not influenced by physiologic changes, such as diet, exercise, sweating, etc. Only when the kidneys are badly impaired do creatinine values rise, and small increases to 3 or 5 mg. per cent are of grave prognostic significance.

Blood Sugar.—Blood sugar is derived almost wholly from the food, the carbohydrates contributing the largest amount. According to the calculations used by clinicians treating diabetes in pre-insulin days, about 50 per cent of protein is converted to glucose and about 10 per cent of fat. These figures may obtain for the severe diabetic but are probably quite variable, and in the normal body such high conversion rates probably do not obtain. In the process of digestion all the carbohydrates are converted to monosaccharides, mostly glucose, and transported to the liver where they are converted into animal starch, glycogen. Most of this is stored in the liver, but part is immediately reconverted into glucose and enters the blood stream. Glycogen is the reserve or storage energizer and is always reconverted into glucose before entering the blood stream for utilization by the muscles. The muscles store a small amount of glycogen.

The glucose in the blood is maintained at a fluctuating level, at from 80 to 120 mg. per 100 c.c. of blood. Exercise depletes it, and a meal usually raises it. This postprandial glycemia rarely rises above 140 mg.

In diabetes the blood sugar level is always disturbed. Postprandial hyperglycemia is high and prolonged. Even in the fasting state in the diabetic body, the blood sugar level is high.

Other conditions which may cause hyperglycemia are hyperthyroidism, severe nephritis (because the renal threshold for the excretion of sugar is raised), brain injuries which affect the sugar center in the fourth ventricle (this must be very rare), pernicious anemia, fractures "without relation to location or severity." (Kroeke.)

Hypoglycemia is most commonly seen in ordinary clinical practice in overdosage with insulin. It may be present in Addison's disease, myxedema, cretinism, muscular dystrophy. Hyperinsulinism from overactivity of the islets of Langerhans due to a tumor has been described.

The Glucose Tolerance Test for blood sugar is the only reliable method of assaying the presence and severity of diabetes.

The patient should have no food after 7 P.M. of the day before the test. The next morning the fasting blood sugar is determined, and the patient is then given 100 Gm. of glucose in solution. Blood is removed for blood sugar determination at the end of half an hour, and at one hour, two hours, and three hours. A variation in technique is the two-dose, one-hour test in which two doses of glucose (50 Gm. each) are given thirty minutes apart. The fasting blood sugar is determined before the first dose and another blood specimen is taken after the second dose.

The first method is the usual one in clinical practice. The results are given the physician in the form of a graph or curve. In a normal person, after the ingestion of 100 Gm. of glucose, the blood sugar level rises to around 150 mg. at the end of the first hour and drops back to normal at the end of the second. In the diabetic, the increase in blood sugar continues through the second hour so that the level may reach 230 mg. per cent or more and remain high (circa 200 mg. per cent) at the third hour, not reaching the original level even at the end of the fourth hour.

The simultaneous determination of the urinary sugar will provide valuable information concerning the renal threshold. Renal glycosuria, a condition in which there is sugar in the urine even when the blood sugar level is very low, can be differentiated from diabetes only by the glucose tolerance test.

The two-dose, one-hour test of Exton and Rose depends, in principle, on the stimulating effect of glucose ingestion on the islets of Langerhans in normal bodies. In the normal body, there will be less elevation of the blood sugar level after the second dose of glucose than after the first. In the diabetic, the second reading is higher than the first.

The Glucose Tolerance Test should be done (1) in all persons over forty-five years of age who apply for a complete physical examination; (2) in the presence of persistent glycosuria; (3) in diabetes, to determine the severity of the condition, (4) in unexplained periodic weakness or tremulousness which suggests hyperinsulinism.

Carbon Dioxide Combining Power of Blood Plasma.—The reaction of the body, which is slightly on the alkaline side of neutral, is maintained by a complicated series of reactions which involve exchange between a group of weak alkalis, mostly carbonates and phosphates, which constitute the so-called buffer system of the blood. The continuance of these reactions is a vital function of the body, either acidosis or alkalosis in any marked degree meaning death to the organism.

The reaction of the body can be measured by the hydrogen ion concentration or pH of the blood. In health, its range is very narrow, from 7.28 to 7.41 with an average of 7.36, and even in disease the extreme degrees of variation compatible with life are only from 6.9 on the acid side to 7.8 on the alkaline side.

The most practical and satisfactory way of measuring the reaction is by determining the carbon dioxide combining power of the blood plasma.

The factors responsible for the constancy of the body reaction are (1) physicochemical and (2) physiologic. (Bard: *MacLeod's Physiology in Modern Medicine*, The C. V. Mosby Co., 1938.)

1. *Physicochemical Factors.*—The carbonate buffer system of the blood consists of sodium bicarbonate (NaHCO_3), and the phosphates are the dibasic (Na_2HPO_4) and monobasic (NaH_2PO_4) sodium salts.

The carbonate system also plays a part in maintaining neutrality by eliminating carbon dioxide formed in tissue metabolism. Carbon dioxide combines with sodium carbonate to form sodium bicarbonate which is broken down in the lungs again, releasing sodium carbonate.

(The kidney also functions to return buffer substance to the plasma. When sodium salts pass through the glomerulus the sodium ion is replaced by ammonia, returning it to the plasma.)

2. *Physiologic Factors*.—Pulmonary ventilation and the renal output of acid and base.

"The *pulmonary ventilation* is closely adjusted according to the hydron concentration of the respiratory center, and ordinarily changes in CO_2 tension of the blood have a greater and more direct effect upon it than anything else.

When there is a reduction in the denominator of the fraction $\frac{\text{CO}_2}{\text{NaHCO}_3}$ because of introduction of an acid other than carbonic, the hydron concentration of the blood increases and the CO_2 tension rises. Breathing is at once stimulated and remains so until the numerator (CO_2) is reduced to correspond with the reduction in the denominator (NaHCO_3); when the ratio is again 1:20 (it may now be 0.5:10 or even 0.25:5) the pH is restored and breathing quiets down again. If the acid responsible for the change is CO_2 , the numerator of the fraction increases first, but the denominator is also increased by alkali made available by the passage of chlorine into the erythrocytes; breathing is again stimulated, but it returns to normal when the ratio of carbonic acid to bicarbonate is again 1:20, though this may now mean a ratio of 1.5:30 to 2:40. Conversely, when alkali is introduced into the blood, breathing is depressed until enough CO_2 is retained to restore the ratio to the normal 1:20; if CO_2 is lost (as at high altitudes or in any hyperpnea due to something other than increased CO_2 tension in the blood) there is a relative excess of NaHCO_3 , and this is taken care of at least in part by excretion of an alkaline urine." (Carl F. Schmidt in Bard: *Macleod's Physiology in Modern Medicine*, The C. V. Mosby Company, 1938.)

The alkali reserve then can be measured by the amount of carbon dioxide that can be liberated from a known amount of plasma by the addition of a weak acid in the presence of a partial vacuum (method of Van Slyke and Cullen).

Normal values range from 55 to 80 volumes per cent.

Acidosis may be mild or compensated, in which case the readings are from 55 to 40 per cent. Moderate acidosis gives readings of 40 to 30 volumes per cent. Uncompensated acidosis gives readings below 30 per cent.

Joslin's rule is that in diabetic subjects when the CO_2 combining power is found to be 20 per cent or less, the classification is diabetic coma. He records one case in which the patient was admitted to the hospital with a reading of 4 per cent; he recovered as a result of prompt and energetic treatment. Baker (Arch. Int. Med. 58: 373, 1936) reports two cases in which the readings were 2 volumes per cent. Both patients recovered.

Moderate alkalosis is indicated by readings of 90 volumes per cent; severe alkalosis by readings of 125 volumes per cent.

Acidosis occurs in diabetic coma, nephritis, diarrhea, and intestinal fistulas with loss of pancreatic fluid. The mechanism in diabetic coma is due to incomplete metabolism of the fats, resulting in the appearance of beta-oxybutyric acid, diacetic acid, and acetone. This is preceded by a sharp breakdown in

the diabetic body's ability to utilize glucose, resulting in hyperglycemia. Clinically it is caused by breaking dietary restrictions, neglect of the use of insulin, or severe infection. The acidosis of nephritis is due to the kidney's inability to produce ammonia, forcing the utilization of sodium for neutralization of acids in the urine. In severe and prolonged diarrhea the colon absorbs sodium from the blood. In pancreatic-intestinal fistula, the loss of pancreatic juice, with its high alkali content, depletes the alkali reserve.

Alkalosis occurs in mountain sickness, fevers, hysteria, encephalitis (hyperventilation), high intestinal obstruction, vomiting of any kind which results in loss of hydrochloric acid, and when excessive alkalization is allowed in the treatment of peptic ulcer (the last a very rare occurrence).

Blood Phosphorus.—Phosphorus is present in the blood as inorganic phosphates, nucleotides, phosphate esters, and as lipids, such as lecithin, cephalin, and sphingomyelin. Phosphorus is derived largely from food fats. The inorganic phosphates play an important part in metabolism. They are buffer substances for the maintenance of normal acid-base equilibrium. They have something to do with intermediate carbohydrate metabolism. They are directly concerned in the formation of bone and in calcium metabolism. Deficiency of phosphorus prevents the formation of calcium phosphate.

The level of blood calcium is higher in children than in adults, due to active bone formation. The childhood range is from 4 to 7 mg. per cent, the adult range is from 2 to 5 mg., and the average is 3.5 mg. per cent. The phosphorus level should be determined in rickets, osteomalacia, and nonunion of fractures.

In hyperthyroidism there are high calcium and low phosphate percentages. As improvement occurs, the values tend to return to normal.

In diabetes the normal phosphorus diurnal fasting variation tends to disappear. Normally after ingestion of glucose, the blood phosphorus level is lowered. As the blood sugar decreases, the phosphorus level returns to normal. In the diabetic patient these phosphorus changes do not occur, at least not to the same degree as in normal persons, and the degree of diminution is considered an index of the severity of the condition. Such tests are seldom necessary.

Phosphatase.—Phosphatase is an enzyme present in bones, kidney, and striated muscles, which liberates inorganic phosphorus for deposition of calcium phosphate in bones, the excretion of phosphate salts in the kidney, excretion of bile, the maintenance of phosphate buffer, and in the physiology of muscle contraction.

There are two forms of serum phosphatase—acid and alkaline.

"Acid" Phosphatase.—Blood serum of patients with metastasizing carcinoma of the prostate gland contains acid phosphatase. Acid phosphatase is found in normal prostate and seminal fluid also. Metastasizing prostatic carcinomatous bone lesions are associated with a marked and sudden increase in acid serum phosphatase. (Gutman and Gutman: *J. Clin. Investigation* 17: 473. 1938.)

Physiologic elevations of phosphatase are observed in pregnancy, after ingestion of vitamin D substances, in alimentary glycosuria, and after exposure to sunlight and ultraviolet light.

In osteoplastic bone lesions (destructive sarcoma and bone metastases of breast cancer especially), obstructive jaundice (increase), and kidney disease (decrease due to destruction of the enzyme along with the kidney cells), there are pathologic variations in alkaline serum phosphatase. In Paget's disease, osteitis fibrosa cystica, and osteogenic sarcoma, the values are elevated. They remain normal in bone tuberculosis, osteomyelitis, and Ewing's tumor.

Alkaline phosphatase is increased in jaundice due to obstruction. When it accumulates in the bone to the point of overflow, it escapes into the blood and is excreted in the bile. When the excretion of bile is interfered with, it accumulates in the blood. This is used as a test to differentiate obstructive from hepatogenous jaundice. In obstructive jaundice the values exceed 10 Bodansky units. In catarrhal jaundice they rarely are that high, and in jaundice due to destruction of liver cells they remain low.

Blood Cholesterol.—Cholesterol is an unsaturated secondary alcohol which is soluble to an appreciable degree only in bile. It is present in liberal amounts in the tissues and fluids of the body where it exists both as free cholesterol and as esters combined with fatty acids. Part of the blood cholesterol is derived from animal food. Since plants cannot synthesize cholesterol, none is derived from vegetable food. The greater part of cholesterol in the body, however, is derived from synthesis. The ability of the animal body to synthesize cholesterol is shown by the fact that it is present in the feces of animals which eat only plant food. The site of the synthesis is not certain, but probably the cholesterol of the bile may result from the breaking down of erythrocytes and other cells, by the hemolytic action of the bile. The mucosa of the intestine may also yield cholesterol.

Normally blood cholesterol values are quite constant, showing little significant relation to the ingestion of cholesterol-bearing foods. It is not unusual, however, to find a moderate temporary rise in blood cholesterol a few hours after the ingestion of food. Cholesterol determinations then must be made after a fasting period of at least five hours.

The clinical conditions in which blood cholesterol determinations may be of significance are:

Xanthomatosis.—In this condition, usually a complication of diabetes, there is a disturbance of lipid metabolism with an excessive accumulation of cholesterol deposited as yellowish nodules in the skin, mucous membranes, or tendons. Blood cholesterol values as high as 845 mg. per 100 c.c. of blood have been reported in xanthomatosis. Schüller-Christian's disease is an osseous form of xanthomatosis appearing in children. It presents bony defects in the skull, diabetes insipidus, and exophthalmos. Closely related are probably Gaucher's disease, Pick-Niemann's disease, and Tay-Sach's disease.

Lipoid Nephrosis.—Here hypercholesterolemia is a characteristic manifestation.

Jaundice.—In diseases of the hepatic and biliary systems, blood cholesterol determinations have been suggested as an aid in the differentiation between types of jaundice. The values are high in obstructive jaundice. The relation of cholesterol to gallstone formation is evident, but there is difference of opinion as to blood cholesterol increase or change during the process.

Thyroid Gland Disease.—Epstein and Lande (Arch. Int. Med. 30: 563, 1922) maintained that blood cholesterol levels bear an inverse relationship to the basal metabolic rate. They found the blood cholesterol to be low in hyperthyroidism and high in myxedema and hypothyroidism. This contention has not gone unchallenged. Gardner and Gainsborough (Brit. M. J. 2: 935, 1928) found no constant relationship, but that high levels in hypothyroidism were much more constant than low levels in hyperthyroidism. This seems to represent the consensus of opinion today.

Atheromatosis.—Aschoff first demonstrated that atheromatous plaques of the aorta contain a large quantity of cholesterol. In a case of hypertension at a relatively early age (forty-six) with recurrent hemiplegia and final exitus from massive intracranial hemorrhage, I saw at autopsy the basilar arteries beaded like a child's necklace with cholesterol nodules. The subject is a fascinating one for clinical speculation, but little help has come from blood cholesterol determinations.

Normal pregnancy shows a consistent rise in blood cholesterol.

Low blood cholesterol values are found in many anemias, particularly of the hemolytic type, in infections and acute hepatic disease, and in the manic phase of manic-depressive psychoses.

Blood Amylase.—The starch-digesting enzyme, amylase or diastase, secreted by the pancreas, salivary glands, and possibly by the duodenal mucosa, enters the blood, and maintains a very constant level. It is excreted in the urine. Experimental ligation of the pancreatic duct produces a marked elevation of blood amylase. Theoretically its determination should be of value in pancreatic duct obstruction and in acute pancreatitis, but practically it is of little value. Low values have been observed in hepatitis, the toxemias of pregnancy, pneumonia, cirrhosis of the liver, abscess and carcinoma of the liver, and in the idiopathic steatorrhea of nontropical sprue.

Blood Calcium.—Calcium is present in the blood serum. It is concerned in the functions of the growth of bone, clotting of blood, muscular tone and contraction, and in the irritability of the nervous system. The level of calcium in the blood serum is controlled almost entirely by the parathyroid glands. Alterations in parathyroid function make variations in the blood calcium. The outstanding clinical condition associated with calcium deficiency is tetany. In hyperparathyroidism the values are high.

Blood Iodine.—Iodine is essential to thyroid functions and determinations of blood iodine have been employed in studies of thyroid metabolism. The amount of iodine in the blood is so small that a special unit of measurement, the microgram, has to be employed.

In a series of patients with hyperthyroidism the iodine level was found to vary from 2 to 155 micrograms per cent with an average of 21. (Parker in *Textbook of Clinical Pathology*, by Roy R. Kracke and Francis P. Parker, Williams and Wilkins Co., 1940.) In hypothyroidism, determinations are of no value.

Proteins.—The three chief proteins of the blood are fibrinogen, serum albumin, and serum globulin. Clinically only the serum albumin and serum globulin are determined with any reliable results. The site of the formation of albumin and globulin is not known. Their functions are (1) to carry buffers and (2) to preserve the normal fluid balance between the blood and the tissues. They can pass through the semipermeable capillary walls and exert osmotic pressure which causes fluid to pass from the tissues into the vessels, unless the blood pressure is too high to permit this. The balance between blood pressure and osmotic pressure results in a normal fluid distribution in the body. In the arterial end of the capillary loop, the pressure is high and the flow is toward the tissues. In the venous end of the capillary loop, the pressure is low, and the flow is toward the circulating blood. When the serum proteins are depleted, the venous pressure may be greater than the osmotic pressure of the plasma, and fluid then moves toward the tissues, resulting in edema.

Normal serum protein is from 6 to 8 Gm. per 100 c.c. of blood. Usually the albumin constitutes 4.5 to 5.5 per cent of this and the globulin 1.5 to 3 per cent. This ratio is called the albumin-globulin ratio (A-G ratio) = 1.5 to 2.5:1. High total values are found in diarrhea and vomiting (any states of dehydration) with no change in the ratio. In certain states, such as multiple myelomata, advanced carcinomatosis, kala-azar, lymphogranuloma inguinale, etc., the total protein is raised almost entirely by rise in globulin.

With reduction of the total protein, edema occurs. Deficient protein intake, malnutrition, and starvation are examples.

Albuminuria and ascites produce protein loss. The edema of *lipoid nephrosis*, second stage glomerulonephritis, and amyloid disease is due to loss of the albumin fraction, and to increase in the globulin fraction which the body manufactures to replace the albumin so that in these conditions there is a reversal of the A-G ratio. Edema occurs when the albumin value falls below 2.5 and the total protein below 5.5.

Blood Chlorides.—Most of the chlorides in the body are in the form of the inorganic sodium chloride, but some are organic bound to the lipoids. The chlorides in the blood and in the tissues preserve the fluid balance of the body, and anything which disturbs this value, such as excessive vomiting, pernicious vomiting of pregnancy, etc., will produce serious changes. Abnormal diuresis, as in diabetes, and extensive burns with loss of chloride from the exudation will also disturb this balance. Heat exhaustion with excessive sweating is accompanied by salt loss and produces muscular and abdominal cramps. Increased chlorides are found in nephritis and renal edema.

In all of these conditions, knowledge of the chloride content of the blood may be required.

Sodium and potassium determinations may be useful in a number of conditions, such as shock, disturbances of the acid-base balance in connection with studies on the carbon dioxide combining power of the blood plasma, etc. In *Addison's disease*, there is a decrease of sodium and increase of potassium, and replacement of the sodium by the use of sodium chloride may alone be sufficient treatment for such a case.

Chapter 19

THE SPUTUM

The accomplished clinician will always look in the sputum cup on the bedside table. He may find only burned matches and cigarette stubs and no spit, but negative evidence is as valuable as positive.

The **gross appearance** (amount and character) of the sputum gives information quite as valuable as the microscopic examination.

Note:

1. The large amount, the pus and mucous sputum of bronchitis, bronchiectasis, and tuberculosis.
2. The nummular or sandy pus sputum of lung abscess or empyema with bronchial fistula.
3. The frothy glairy sputum of asthma.
4. The tenacious, rusty sputum of pneumonia.
5. The pink frothy sputum of passive congestion.
6. The bloody sputum of infarct or hemorrhage.
7. Odor—fetid, rancid, etc.

In a specimen of sputum on a slide or Petri dish against a black background may be seen *cheesy masses* (characteristic of tuberculosis); *Dittrick's plugs* (from bronchitis, consisting of cellular debris, fat, and bacteria, and having a foul odor characteristic of putrid bronchitis and bronchiectasis, but not usually of tuberculosis); *Curschmann's spirals* (small, spirally twisted masses of mucus around a central thread, characteristic of asthma; they are probably casts of the fine bronchioles); *bronchial casts* (rarely one gets a cast of the entire bronchial tree usually in diphtheria, or a hemorrhagic bronchial cast in hemorrhage from phthisis); or *concretions*—lung stones (bits of calcium representing calcified glands that have ulcerated through the bronchus). (See Lyter: Bronchopulmonary Lithiasis, M. Clin. North America 6: 107-117, 1922.) Christian suggests, as a method of bringing out these elements, that the sputum be placed in a 500 c.c. graduate of water and well shaken; the particles are then observed as they sink to the bottom.

Microscopic examination of the unstained or stained smear may show:

1. Charcot-Leyden crystals are colorless, pointed hexagons. They are not usually found in fresh sputum, but in that which has been allowed to stand. They are supposed to be characteristic of bronchial asthma and may be found imbedded in the Curschmann's spirals. They are believed to be derived from the eosinophiles. They are not necessarily associated with asthma but may be present in bronchitis.

2. Hematoiden crystals are found in the sputum of pulmonary infarction, tuberculosis, or any hemorrhagic lung condition.

3. Eosinophiles—the finding may give comfort in a doubtful case of allergic asthma.

4. Actinomyces “sulfur” granules which present a radiating appearance under the microscope.

5. Pneumoconiosis or occupational granules—silicon (sand-dust), marble, coal, iron, asbestos particles may all be found (Lynch and Smith: Asbestos Bodies in Sputum and Lung, J. A. M. A. 95: 661, 1930; Drinker: The Size, Frequency and Identification of Certain Phagocytosed Dusts, J. Indust. Hygiene 7: 307, 1925; Landis: The Pathological and Clinical Manifestation Following the Inhalation of Dust, J. Indust. Hygiene 1: 117, 1919.)

6. Vincent's organism, common in lung abscess, gangrene, bronchiectasis, etc., is a very important finding for therapeutic purposes. Since this organism responds to arsphenamine therapy, syphilis of the lung (which in adults is a clinical myth) is often reported.

7. Parasites and fungi—Echinococcus (affects the lung second in frequency to any organ—134 cases out of a series of 809); trichomonas (little or no significance; larvae of Necator, Strongyloides, and Ascaris; ova of the lung fluke (Paragonimus); blastomyces (Gilchrist's disease, or blastomycosis of the American type is a generalized disease in which skin nodules and lung abscesses occur together, although the skin lesions may appear alone). (See Benham: The Fungi of Blastomycosis and Coccidioidal Granulation, Arch. Dermat. and Syph. 30: 385, 1934.)

8. Pneumococci—important for typing.

9. Tubercle bacilli—when present, of course, they are entirely pathognomonic. They are indeed, a somewhat late sign of the disease, and they are not searched for as assiduously as they once were. It has been estimated that at least 100,000 bacilli per cubic centimeter must be present for detection in an average smear (Wahlin in Krache and Packer's *Textbook of Clinical Pathology*). Absence of the bacilli does not exclude tuberculosis of the lungs. With effort they can be found in many early cases. One hears frequent reports of finding bacilli on the twentieth or thirtieth attempt. If not found in the sputum, the stomach washings should be examined; the effort will be rewarded with success in a surprising number of instances.

Repeated examinations on patients under treatment, giving quantitatively the average number in a smear, have a good deal of prognostic value.

(Clifford, Randall: *The Sputum: Its Examination and Clinical Significance*, Macmillan Medical Monographs, New York, 1932, The Macmillan Co.)

Chapter 20

EXAMINATION OF THE GASTRIC CONTENTS

There is a movement back to the old Ewald-Boas meal, which is a movement all to the good. Drs. Sardioni and Sagal (*The Popularity of the Ewald-Boas Test Meal: Reasons for Its Survival*, Ann. Int. Med. 13: 2134, May, 1940) have spoken for it as has Eusterman (*The Stomach and Duodenum*, Philadelphia, 1935, W. B. Saunders Co.) and indeed, Boas himself (*Vierzig Jahre Probefrühstück*, Deutsche med. Wehnschr. 51: 976, 1925).

The Ewald-Boas test meal should still be standard because of its simplicity. The patient eats a slice of white bread without butter and drinks a glass of water, and the meal is aspirated at the end of an hour. The entire gastric contents are presented for view, and the gross examination is by all odds the most important feature of the procedure.

In 89 per cent of cases Sandroni and Sagal found free hydrochloric acid in sufficient concentration by a single aspiration, and concluded that it is unnecessary to subject patients to the more complicated procedure of fractional aspirations.

The gross examination of the aspirated test meal shows first the total amount of gastric secretion returned. This should always be noted, as it is the most significant single piece of information obtained from the examination of the gastric contents. The actual concentration of free hydrochloric acid in the contents may mean nothing, but a large amount of aspirated contents (100 to 120 c.c.) containing hydrochloric acid, no matter in what concentration, is of clinical significance. The gross contents show also the degree of pulverization of the bread and whether or not there is mucus, both of which are of some significance (although the old slogan "mucus equals gastritis" has gone the way of many other beautiful generalizations).

For many clinicians the mere proof that the gross specimen is acid, as tested by litmus paper, or, at any rate, that free hydrochloric acid is present as shown by a drop of dimethylaminoazobenzol (Topfer's reagent) is sufficient for his conclusions.

By titration it is considered that a value of 20 to 60 degrees of free HCl is about normal. In duodenal ulcer the values are high. In pernicious anemia there is no hydrochloric acid (and the total aspirated amount is small or even nonexistent). In cancer of the stomach hydrochloric acid is usually absent or low. In gastric ulcer the value is high if there is no obstruction. In cholecystitis and cholelithiasis, functional dyspepsia, neurasthenia, and migraine there is no dependable characteristic change. The clinician should always remember the lecture of Carlson (*The Secretion of Gastric Juice in Health and Disease*, Physiol. Rev. 2: 8, 1923) that in normal persons the gastric secretion may vary from hyperchlorhydria to complete in acidity.

Combined acid is the amount of hydrochloric acid that has combined with protein. The combined acid and free hydrochloric acid constitute the total acidity. Lactic acid occurs in states of fermentation, often in cancer of the stomach. Pepsin and rennin may be tested for, but when free hydrochloric acid is present their presence is also assumed.

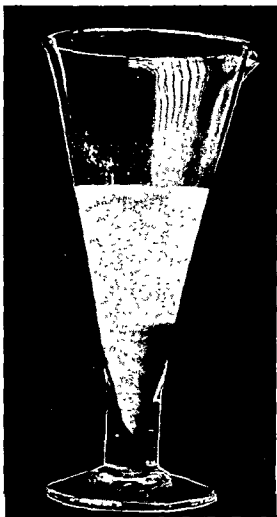


Fig. 71.—Gastric contents removed one hour after ingestion of a piece of unbuttered white bread and a glass of water. The total amount is significant, and also the presence of three layers—head, clear fluid, and mucus. The fragmentation of the head gives a rough idea of the presence or absence of hydrochloric acid.

Blood in the gross specimen is always of grave import. Flecks of blood from trauma by the tube must be recognized and evaluated. Significant blood in the gross specimen either of vomitus or test specimen is digested, granular, and dark brown in color—coffee ground. In hemorrhage from esophageal varices in cirrhosis of the liver the blood is likely to be in clots, as is also the case in massive hemorrhages of gastric ulcer.

The benzidine test for occult blood in the test specimen is of little or no significance.

Fractional Analysis.—Fractional analysis of the gastric contents is done on specimens removed every ten minutes for an hour after the administration of an alcohol meal consisting of 50 c.c. of 7 per cent ethyl alcohol. A curve is plotted, which normally rises to its height at the end of thirty minutes and then falls to approximately the starting level at the end of the hour.

Normal values show about 20 degrees with the first specimen and 60 degrees at the thirty-minute interval.

Hyperacidity shows 40 to 50 degrees with the first specimen, 100 to 120 degrees at the thirty-minute interval, and 70 to 80 degrees at the end of the hour. A curve which continues high after the thirty-minute period is a definite indication of hyperacidity and hypersecretion, and is typically found in duodenal ulcer.

Hypochlorhydria shows a low flat curve, with values of 20 degrees at ten minutes, 30 degrees at thirty minutes, and 10 degrees at the end of the hour.

Achylia gastrica, typical for pernicious anemia, shows 0 to 5 degrees at ten minutes, 10 to 20 degrees at thirty minutes, and 0 to 5 degrees at the end of the hour. Histamine phosphate, when injected subcutaneously in doses of 0.19 mg. per 10 kilograms of body weight, exerts the usual effect of the drug, which is stimulation of the gastric mucosa. (The average dose is 0.5 to 1.0 c.c. of a 1 to 1000 solution, but as this produces the uncomfortable symptoms of abdominal pain, flushing of the face, and fast pulse, it may be well to use a smaller dose on the first administration—0.25 c.c. of 1 to 1000 solution.) The injection is made after the tube has been passed and the fasting contents removed. Five c.c. are aspirated every ten or fifteen minutes for one hour, although some clinicians prefer to leave the tube in three hours.

The most important application of the histamine test is for pernicious (Addisonian) anemia. Since in this condition the gastric mucosa is completely atrophied, histamine stimulation produces no results. It is doubtful, however, whether the results are significant enough to justify the trouble. Mention should be made of the method now becoming routine, namely, that of examining the gastric contents for tubercle bacilli in cases in which they have not been recovered from the sputum.

Examination of the duodenal contents is of questionable value. Lyon's method of gall bladder drainage through the duodenal tube is accomplished by the use of a magnesium sulfate solution which relaxes the sphincter of Oddi and, by Meltzer's law of contrary innervation, causes the gall bladder to contract. Lyon distinguished three kinds of bile thus obtained which appear more or less in succession: A bile, light, yellowish, mixed with duodenal contents, coming from the common duct; B bile, which appears in ten to thirty minutes, is darker, heavier, and more viscid and Lyon claimed that it came from the gall bladder; C bile is golden yellow, clear, less syrupy, and comes from the liver, that is, the biliary capillaries. These distinctions are, however, more theoretical than real. Bassler, Luckett and Lutz (Am. J. M. Sc. 162: 674, July, 1921) observed patients during laparotomy with a duodenal tube in place, and found that during the appearance of B bile the gall bladder did not empty, so that B bile is likely to be the bile from the capillaries and washings from the common duct.

Chapter 21

EXAMINATION OF THE STOOL

Examination of the stool is principally done for detection of animal parasites or their ova. It does not fall within the scope of this book to describe all the varieties and appearance of these parasites. The clinician must presume that the laboratory technique is competent and that if a particular parasite or its ovum is reported, he can proceed to treatment along the lines laid down in the standard texts.

Gross appearance of the stool is important and in hospital practice should be a routine. Gross examination of the stool should always be made when the complaint is diarrhea.

A normal stool, according to Dr. Sippy's definition, is the size, shape, and consistency of a peeled banana; and of some shade of brown, green or black, depending on the diet.

Abnormal colors vary from the tarry black, slimy stool caused by hemorrhage into the gastrointestinal tract, to the white or clay-colored or putty-colored stool of biliary obstruction. The clinician will use his judgment in interpreting variations of these colors.

Stools indicating the presence of blood should be repeatedly examined in the presence of the syndrome of internal hemorrhage. This is a neglected syndrome, too often missed. An example of this is the case of a successful businessman (able to afford the best medical advice) who, while on a business trip, was overcome every evening by a sensation of faintness and breathlessness, so that he was compelled to lie down for an hour or so after dinner. He consulted eight diagnosticians in eight large cities, and only at the last station did the diagnostician take his hemoglobin and examine his stool, both of which indicated internal hemorrhage.

Large, foamy, fatty stools occur in pancreatitis, pancreatic deficiency, sprue, and celiac disease.

The stools of constipation consist of small scybalous masses with a coating of mucus, or more often are quite normal in appearance, being simply a formed stool.

The stools of ulcerative colitis, amoebic dysentery, or any ulcerative lesion of the intestines are liquid and consist largely of pus and blood with some fecal matter and undigested food particles.

Ribbon stools of rectal carcinoma are rarities even in a series of cases of rectal carcinoma.

Mucous stools, the stools of mucous colitis, are typically masses of opaque white mucous casts. Patients frequently have the syndrome of mucous colitis without the characteristic stool. Mucus itself is not a specific indication of anything, as it may result from any irritation.

Fermentation, the indication of a somewhat neglected condition of fermentative diarrhea or colitis, may be demonstrated by placing the stool in a Mason jar; the bubbles of fermentation are easily observed after an interval

The benzidine test for occult blood is of some value. It must be assured that the patient has not eaten any meat for at least two to three days. To obtain a specimen for the benzidine test the patient is given a one ounce ointment jar and a tongue depressor and instructed to take a portion of the stool up on the tongue depressor and transfer it to the jar. The test is very delicate and must be critically interpreted in that light, but it often gives positive results in peptic ulcer or gastric cancer when no blood can be demonstrated in the vomitus or gastric contents.

Microscopic examination of the stool for food remnants is of little value, in spite of the emphasis put on it in past times. Meat fibers may be present in the stool in enormous amounts after a meal rich in meats, but they do not indicate incomplete digestion. "Much has been written of starch indigestion, but undigested starch is nevertheless a rare finding in the stool of adults." (Cheney: *The Technic of Stool Examination*, M. Clin. North America 6: 1567, May, 1923) Vegetable remnants may be mistaken by the inexperienced for the ova of parasites.

Chapter 22

FUNCTIONAL TESTS

Functional Liver Tests

NORMAL VALUES

1. To test bile retention:
 - (a) Icteric index—2.5 to 5.0.
 - (b) Van den Bergh:
 - Direct—10 to 30 seconds after addition of reagent—a reddish-violet color.
 - Indirect—no color reaction until the addition of alcohol.
 - (c) Bilirubin excretion test—retention of 5% at end of four hours.
2. Carbohydrate function tests:
 - Galactose—40 Gm. by mouth—less than 2 Gm. passed by urine.
 - Levulose—50 Gm. by mouth. Blood sugar does not rise above 30 mg. Total urinary output 130 mg.
3. Tests of excretion function:
 - (a) Bromsulfalein (5 mg. per kilo body weight intravenously); 5 minutes later 35 per cent should be in the blood; 30 minutes later none in the blood. (b) Rose-Bengal test—50 per cent of the dye will be removed in 2 minutes.
 - (c) Azorubin S—discoloration of duodenal contents in 15 to 30 minutes.
 - (d) Hippuric acid synthesis (6 Gm. by mouth)—3 to 3.5 Gm. excreted in urine in 4 hours.

When the subject of a functional test for the liver arises, the inevitable question is "Which function?" The multiplicity of functions which the liver performs decreases the value of any one test. No single procedure will test the hepatic function as a whole, as the phenolsulfonphthalein test may be said to test the kidney function as a whole. In fact, the results of a variety of tests can hardly be said to give really reliable information concerning the functional capacity of the liver.

The functions of the liver are:

1. *The formation of bile*; the excretion of bilirubin, bile salts, and acids.
2. *Carbohydrate Metabolism*.—The liver receives simple sugars, monosaccharides, from the intestine, converts them to glycogen, stores glycogen, reconverts it into glucose, and releases it to the blood.
3. *Protein Metabolism*.—Urea formation and deamination of the proteins.
4. *Fat Metabolism*.—Desaturation and oxidation of fatty acids; formation of ketone bodies and cholesterol esters, and, to a certain extent, the storage of fats and cholesterol.

5. *Detoxification of deleterious products* formed in the gastrointestinal tract and carried by the portal system to the liver.

6. *Coagulation ferment formation*—fibrinogen, prothrombin, and anti-thrombin.

7. *Reticulo-endothelial Activity*.—Destruction of red cells and the removal of foreign bodies from the blood stream.

8. *Storage*—

(1) Iron.

(2) Fat soluble vitamins—A, D, and K.

(3) E.M.F. (erythrocyte-maturing factor).

To test the function of bile formation there have been devised:

(1) The icterus index determination.

(2) Van den Bergh reaction.

These are valuable only in the presence of jaundice.

(3) Bilirubin excretion test.

To test carbohydrate metabolism there are the galactose and levulose tolerance tests.

To test the excretory functions we have:

(1) The bromsulfalein test.

(2) The Rose-Bengal test.

(3) The sodium-phenoltetraiodophthalein test.

(4) The azorubin S test.

To test detoxification function we have the hippuric acid concentration test.

Conditions under which the clinician may wish to test the function of the liver are:

(1) To ascertain the extent of liver damage after recovery from catarrhal jaundice or a cholecystitis.

(2) As a pre-operative precaution, and for the choice of an anesthetic

(3) Before the administration of arsenicals in the treatment of syphilis

(4) Possible cirrhosis of the liver or hepatic damage from chronic alcoholism. In an alcoholic when the liver cannot be palpated, but there has been hematemesis or rectal bleeding, or the spleen is palpable, or without any of these signs, simply chronic alcoholism—a reliable test would be very valuable.

Perhaps the two tests which are most dependable for routine use are the hippuric acid concentration test and the bilirubin excretion test. They can be done together at the same time. The subject will have to appear in the fasting state and drink no water for four hours while tests are being conducted. They act as a check on each other. However, positive conclusions should not be drawn. I know of one subject who was warned of his dire hepatic condition seven years ago as a result of a poor showing on the bilirubin excretion test, who is still going strong with no diminution of vigor, change of habits, or evidence of liver damage. Such experiences discourage dogmatism in interpreting liver function tests.

A brief description of all the tests mentioned above follows:

Bile Formation.—Red cells are broken down by the reticulo-endothelial system releasing hemoglobin, the porphyrin fraction of which is transferred into bilirubin. There is formed a bilirubin-protein complex which does not pass the kidney threshold—bilirubin Type I. This is carried by the blood to the parenchymatous cells of the liver, where its protein component is removed and it is changed to bilirubin Type II (Elton's bilirubinate). It is excreted into the bile ducts and passes into the intestine. In the intestine bilirubin Type II is converted by bacterial action into urobilinogen: most of this is excreted in the feces, but a part is reabsorbed into the blood stream. Of the part returned to the blood, a part is re-excreted in the bile, a part converted into hemoglobin, and the remainder excreted by the kidneys either as urobilinogen or as urobilin.

Icterus index indicates the amount of bilirubin present in the serum. This is measured directly by a color test against a standard potassium dichromate solution. Normal values are 2.5 to 5. Values between 6 and 15 indicate "latent jaundice" or slight retention. Values over 15 are usually associated with obvious jaundice. Either obstructive jaundice, or hemolytic anemia will increase the readings.

Van den Bergh Reaction.—This is intended to differentiate obstructive from hemolytic jaundice. When sulfanilic acid and sodium nitrite are added to a solution of bilirubin, a colored compound, azobilirubin, is formed. When Type I bilirubin is present, no color reaction is obtained until the serum has been treated with alcohol. This is the *indirect* reaction, indicating hemolytic anemia. With Type II bilirubin the serum, within 10 to 30 seconds after the addition of the reagent, assumes a reddish-violet color. This is the *direct* reaction indicating obstructive jaundice. The *biphasic* reaction indicates that both types are present: a red color appears first and upon standing, a violet color develops.

Bilirubin Excretion Test.—The basis of this test is the ability of the normal liver to excrete an excess of bilirubin in a given time. An amount of bilirubin—1 mg. per kilogram of body weight—is injected intravenously, and at the end of four hours blood is taken from the other arm and the amount of bilirubin present is quantitatively determined. A retention of more than 5 per cent of the injected serum is considered abnormal.

Urobilinogen in the urine is absent in total obstruction of the bile ducts, because then the precursor has been cut off.

Carbohydrate Function Tests.—Galactose and levulose are simple sugars which, after absorption, are not converted into glycogen if any considerable amount of liver damage exists, therefore they spill over in the urine.

Forty grams of galactose in 400 c.c. of water are given by mouth on a fasting stomach and specimens of urine are collected hourly until two sugar-free specimens are obtained. Normal subjects will pass from 0 to 2 Gm. of sugar in the urine. Amounts between 2 and 3 Gm. are suggestive and over 3 Gm. indicate definite liver damage.

Fifty grams of levulose in 400 c.c. of water are given by mouth on a fasting stomach. Blood is taken for sugar determinations 1 hour and 2 hours later.

of foreign substances, such as dyes; and (3) measurement of the excretion of substances which the kidney normally excretes.

Many such tests have been devised, but the clinician would do well to direct his laboratory to confine its examination to a few which give dependable information about the various factors in the physiology of the kidney.

Dr. Donald D. Van Slyke (*New York State J. Med.* 41: No. 8, April 15, 1941) states that as a result of comparing various tests of renal function at the nephritic clinic at the Rockefeller Hospital, they have reduced their routine tests to two: (1) the urea clearance as an indicator of changes in glomerular excretion and (2) the urine specific gravity test as a measure of tubular reabsorbing power. To these I think may well be added the old reliable phthalein excretion test which tests the ability of the tubules to excrete foreign unnatural substances.

The modern theory of renal physiology as developed by Cushing, Richards, Marshall, Smith, Shannon, Rhoades and others (see Smith, H. W.: *The Physiology of the Kidney*, New York, 1937, Oxford Univ. Press) gives the clinician a valuable visualization. It is well summarized in the words of Van Slyke:

"As the blood courses through the glomerular capillaries, a part of the plasma water is filtered out into the capsular spaces of the glomeruli. This fraction appears to be usually about 20 per cent of the total plasma water. With this water are filtered all the sugar, salt, urea, uric acid, creatinine, and other noneoloidal substances dissolved in the water as it circulates in the plasma. The rate of glomerular filtrate formation in man appears to be at the rate of about 6 L. per hour, or 150 L. per twenty-four hours.

"The filtrate is formed by mechanical filtration. All the dissolved substances of the plasma are in it, not only those such as urea and uric acid, which are waste products to be gotten rid of, but also the glucose and bicarbonate, which are needed in the body. Other substances such as the water and salt of the filtrate are filtered in much greater amounts than the body can afford to lose. To let the waste products pass into the urine and at the same time to save the blood substances that are needed in the body, the cells lining the tubules exert a highly selective action in reabsorbing the needed substances and letting pass into the urine the waste products and such amounts of sodium chloride, water, and other partially needed materials as are required to maintain normal volume and composition of the body fluids.

"Besides their power of selective reabsorption the tubules have a reserve function of excretion; the tubular cells can pick foreign substances, such as injected dyes, from the blood and extrude them into the tubular lumina, whence they pass into the urine. This function appears to have no important part in man in the excretion of naturally occurring urinary substances; it is a reserve power used to handle foreign substances that cannot be excreted by means of glomerular filtration. Tubular excretion is the process by which injected phenolsulfonphthalein is excreted."

Specific gravity tests depend upon restricting fluid intake for a certain length of time and measuring the specific gravity of the urine during the latter part of the period. According to Addis' method (*Arch. Int. Med.* 30: 559, 1932), the patient is put on a dry diet for twenty-four hours—from one morning to the next. No fluids are given from after breakfast one morning until break-

fast the next morning. The urine is collected during the last twelve hours of this period and the specific gravity determined. If much albumin is present, the albumin content must be determined and correction made for its effect on the specific gravity; this is done by subtracting from the observed specific gravity 0.003 for each per cent of protein in the urine. A person with normal kidneys will void, during the twelve hours of the test period, a urine with a specific gravity of over 1.026.

Urea Clearance Test.—A normal adult under ordinary conditions of urinary flow, excretes per minute the amount of urea contained in 75 c.c. of blood.

In performing the test two glasses of water are given to promote a full flow of urine. The first glass of water is given, and the subject empties his bladder, but the specimen is not saved. At the end of an hour the subject again empties his bladder, and the specimen is saved. A sample of blood is drawn (2 c.c.). The subject then drinks his second glass of water. At the end of the second hour the subject again voids completely, and the specimen is saved.

After urine and blood analysis, the urea clearance is indicated as

$$\text{Percentage of normal urea clearance} = 100 \times \frac{\text{Concentration of urea in diluted urine}}{\text{Concentration of urea in the blood}}$$

The usual range is between 75 and 130 per cent of average normal.

The Phenolsulfonphthalein Test.—

1. Give the subject about two glasses (300 to 400 c.c.) of water.
2. Twenty minutes later have him empty his bladder; discard the specimen.
3. Give 1 c.c. of sterile phenolsulfonphthalein solution intramuscularly.
4. One hour and ten minutes later the subject empties the bladder; save all of this specimen. (The extra ten minutes represents the average time from the injection to the appearance of the dye in the urine.)

5. Two hours and ten minutes after the injection, the subject empties the bladder again. The output of phenolsulfonphthalein in each specimen is estimated. Normal standards are 40 to 50 per cent of the dye eliminated the first hour; 60 to 75 per cent eliminated in two hours. In slight impairment of renal function total excretion is 40 to 60 per cent, in moderate impairment, 25 to 40 per cent, in marked impairment, 10 to 25 per cent, in maximal impairment, below 10 per cent.

Interpretation of the Tests.—The fall of urea clearance is a measure of the proportion of glomeruli destroyed. When 50 per cent of glomeruli are destroyed, the fall is about 20 per cent. As destruction of glomeruli falls below 50 per cent, urea clearance falls at an increasingly rapid rate. (Hayman and Johnston: J. Clin. Investigation 12: 877, 1933.) Shock and other temporary influences will retard urea clearance as well as glomerular destruction.

In acute nephritis, when severe, the urea clearance falls to low levels and the specific gravity to the uremic range in the neighborhood of 1.010. As recovery occurs, the figures improve and are the best index to the improvement.

The clearance may reach normal long before the specific gravity improves. In mild degrees of renal damage, the specific gravity is more sensitive than the urea clearance. In estimating prognosis in acute nephritis, when the urea clearance has fallen, a beginning of a rise toward normal always occurs within four months if recovery is to follow.

Chronic Nephritis.—Early stages may not show much reduction in clearance, especially in nephrosis with insidious onset. On the contrary, some cases may show early fall of clearance percentages, and prognosis is affected by the rapidity and steadiness with which urea clearance percentages fall. The specific gravity usually falls along with the urea clearance, and when a level of 30 per cent clearance is reached, the specific gravity has usually reached 1.008 to 1.012. From here on, prognosis must depend upon urea clearance because the specific gravity has reached bottom level.

“The relative behaviors of the clearance and specific gravity tests may be summarized by stating that, in most cases, the specific gravity is the more sensitive indicator of mild degrees of damage, while the clearance must be relied upon to indicate changes in the more severe degrees.” (Van Slykes, New York State J. Med. 41: No. 8, 1941.)

Uremia.—When the urea clearance falls to 5 per cent, uremia is either present or imminent.

Chapter 23

THE CEREBROSPINAL FLUID

The cerebrospinal fluid is not examined as a routine, but only when there are indications or suspicions that the results of tests will be contributory. The common clinical indications for examination are (1) meningismus of acute onset indicating epidemic cerebrospinal meningitis, pneumococcic meningitis, tuberculous meningitis, (2) suspected anterior poliomyelitis, (3) encephalitis lethargica, (4) central nervous system syphilis, and (5) spinal cord tumors.

Contraindications for spinal puncture are symptoms of greatly increased intracranial pressure due to subtentorial tumors, intracranial hemorrhage or abscess producing severe pressure symptoms, and certain cases of skull fracture. (There is room for debate concerning the advisability of spinal puncture in head injuries.)

Cisternal puncture is performed more for therapeutic than for diagnostic purposes. It should be tried when there is a dry lumbar tap in meningitis. The deductions obtained from cisternal fluid do not differ from those obtained from fluid by lumbar puncture.

The gross appearance of cerebrospinal fluid is that of a clear, sparkling, transparent liquid. Any cloudiness indicating the presence of pus cells or coloration indicating the presence of blood is significant. In the midst of an epidemic of cerebrospinal meningitis, the presence of fluid that approaches pus in appearance calls for the immediate introduction of antimeningococcic serum through the drainage needle, after a proper amount of cerebrospinal fluid has been removed.

In addition to a description of the gross appearance routine examination of the cerebrospinal fluid includes the following information:

	NORMAL
1. Pressure	70-100
2. Cells per c. mm.	0.5
3. Globulin	0
4. Protein—mg./100 c.c.	0
5. Sugar—mg./100 c.c.	50-75
6. Chlorides—mg./100 c.c.	720-750
7. Nonprotein nitrogen—mg./100 c.c.	12-18
8. Gold sol	000000000

Pressure.—Cerebrospinal fluid flows from the needle under normal pressure at the rate of about 20 to 60 drops per minute, but this is a rough and unreliable method of estimating pressure. Either a straight water tube or U tube mercury manometer should be ready to use as soon as the canal is entered.

The normal pressure in the horizontal position is about 125 mm. of water (75-200 mm. range) and 8 mm. of mercury. The mercury manometer's fault is that it does not show small variations. The water tube has also the advantage that it can be sterilized.

Pressure above 200 mm. of water is regarded with suspicion, although uncomfortable position of the patient, with cramping or straining, breadth holding, etc., must be ruled out. Pressure above 260 mm. is definitely pathologic, and above 300 mm. always denotes, according to James B. Ayer, increased intracranial pressure. Any inflammatory process in the meninges will raise the pressure somewhat. The highest pressures, frequently 700 to 800 mm. of water, are found in brain tumors; a pressure of 1,000 mm. has been recorded. There are constant fluctuations in pressure due to breathing. Low pressures have less definite significance than have high pressures.

The Queckenstedt test consists in making pressure over the jugular veins while the lumbar puncture needle attached to a manometer is in place. This results in rise in pressure unless there is blockage in the spinal subarachnoid spaces (double lateral sinus thrombosis, meningitis, or tumor). The Tobey-Ayer test is positive in lateral sinus or jugular thrombosis on one side: pressure on the jugular vein on the affected side causes no rise in pressure, while pressure on the opposite side causes rise in pressure. The Froin syndrome consists of the presence, in cases of complete subarachnoid block with positive Queckenstedt, of xanthochromia, in the fluid below the block, marked increase in protein and fibrin with a tendency to clot en masse, and the cell count may or may not be increased.

The color of the normal cerebrospinal fluid is that of distilled water. When a clear yellowish color (xanthochromia) is noted, it is due to blood pigment and indicates a previous intracanal hemorrhage or venous stasis due to spinal cord tumor. Yellowish fluids may sometimes possibly—the qualifying adjectives are intentional—be due to jaundice. Some yellow fluids are positive by the benzidine test, some by the van den Bergh test. Ordinary jaundice does not discolor spinal fluid, but long-continued jaundice may.

The Cell Count.—The count for white blood cells in the fluid should be made immediately. Counts of over 10 cells per c. mm. are considered pathologic. In cases of suspected anterior poliomyelitis counts above 10 (usually lymphocytes) have a weighty positive value. In neurosyphilis the cell count is moderately elevated. In epidemic cerebrospinal meningitis or other forms of suppurative meningitis the counts may go as high as 10,000.

Protein normally is present in amounts of 20 to 40 mg. per 100 c.c. Under pathologic conditions it may increase up to 4 grams per 100 c.c., approaching the amount in blood serum. Mixture of one part of spinal fluid with 3 parts of 95 per cent alcohol gives a flocculation that is a rough quantitative measure of protein content. The globulin ring test of Ross-Jones is, however, taken as the standard for quantitative determination. The tests should be done routinely and with great care because the presence of globulin is of the greatest importance, far more so than the gold sol test. In disease of the central nervous system there is permeability of the membranes to serum proteins, and in practically all diseases of the central nervous system there is significant increase of protein in the cerebrospinal fluid.

The colloidal tests include the gold chloride test of Lange, the gum mastic test of Emanuel, and the benzoin test of Guillain. For the gold sol test, which is most commonly employed, a set of 11 test tubes are set up in a rack and

spinal fluid diluted with salt solution is placed in ten of them: tube 11, filled only with salt solution, is the control. The amount of spinal fluid in the tubes is graduated, the amount diminishing toward the right. Then gold solution is added to all the tubes, and they are allowed to stand at room temperature for an hour. The test depends upon the color changes and are expressed in figures thus:

Orange red	0
Red blue	1
Violet	2
Blue	3
Pale blue	4
Colorless	5

Normal reading is 0001100000.

Paretic curve is 5555432100.

Multiple sclerosis has the same curve as the paretic curve, but the fluid has a negative Wassermann.

Tabs dorsalis curve is 0123320000.

Meningitis curve is 0001245310.

(The results are often reported as first zone reaction [555543210], midzone reaction [0000232100], or third zone reaction [0001245310].)

The mechanism of these precipitation tests is not clearly understood. They are not pathognomonic, but taken in connection with other tests they are suggestive and helpful.

Chlorides are low in bacterial meningitis. Sugar is low in acute meningitis and tuberculous meningitis. Neither of these tests, however, is of any real value clinically.

A Wassermann test is done routinely on all spinal fluids except those obviously from cases of acute suppurative meningitis. It is of great diagnostic and prognostic value. In many cases of tabs it is positive when the blood serology is negative. Positive tests may appear years before there are any symptoms or physical signs of central nervous system involvement. A negative Wassermann on the spinal fluid (in the absence of recent treatment and this is a dubious exception) may be considered presumptive evidence of lack of syphilitic involvement (L. W. Diggs in Kracke and Parker's *Textbook of Clinical Pathology*). Reports of one or two positive are not of significance alone, but acquire significance in the presence of other signs and other positive tests.

Diseases in which changes in the cerebrospinal fluid occur:

The Acute Meningitides.—The fluid is pussy in greater or less degree and can be so distinguished by the naked eye. The organism should be identified—the meningococcus, pneumococcus, streptococcus, staphylococcus, *B. pyocyaneus*, *B. typhosis*, *B. coli*, micrococcus, catarrhalis, etc.

Tuberculous Meningitis.—The fluid, which is under moderate pressure (200-300 mm.), is clear or slightly turbid; a clot appears on standing, and there are 50 to 100 cells (polynuclears and lymphocytes in about equal parts). Tubercle bacilli can be demonstrated in 95 per cent of cases at any stage by ordinary staining technique. They are most likely to be found in the clot or pellicle.

Acute Poliomyelitis, Epidemic Encephalitis, and Brain Abscess.—These show similar fluid findings: high pressure, clear or slightly turbid fluid with moderately raised cell counts, usually under 100, slight increase in protein, and variable but abnormal colloidal tests.

Central Nervous System Syphilis.—The fluid varies with various stages and types of syphilis.

Late Primary and Secondary Syphilis.—Moderately increased cell count (lymphocytes 20-50), increased protein, and positive Wassermann, indicating probably an aseptic meningitis. This does not occur in all, but does in many cases during the efflorescent stage. It does not mean that the patient will develop neurosyphilis but some patients presenting this picture do go on to clinical stages.

Acute Meningitis.—This condition occurs during the first year, usually about six months after infection. There is increased pressure (250-350 mm.), increased cell count (500-1,000 cells), positive Wassermann, positive globulin, colloidal tests positive but not specific in type.

Late Neurosyphilis.—Ayer (*Cecil's Textbook of Medicine*, W. B. Saunders, 1940, Fifth edition) distinguishes two types of reaction—strong and weak. The strong reactions are present in paresis, some cases of tabes, and in optic atrophy. Strong reactions indicate severe parenchymatous involvement, and more resistant infection. The weak reactions are present in some cases of tabes and in meningovascular syphilis, when the process is active and advancing. "In by far the larger number of progressive cases of late syphilis the reactions are of this character." (Ayer.)

	STRONG	WEAK
Cytology	10-40 mononuclears	20-80 mononuclears
Total protein	80-125 mg. per 100 c.c.	50-100 mg. per 100 c.c.
Globulin ring test	Strongly positive	Weakly positive
Gold sol	5554321000	1123321000
Wassermann	Strongly positive	Weak, moderate, or strongly positive
Blood Wassermann	Strongly positive	Positive or negative

Under treatment the spinal fluid changes show regression and a return to near-normal conditions. A drop in the cell count is usually the first change, followed by a change in the Wassermann. The gold sol curve is very resistant to improvement toward normal. Even in the presence of clinical improvement, if the spinal fluid changes remain fixed, the prognosis is dubious and grave.

Latent neurosyphilis occurs with clinical signs, but normal or nearly normal spinal fluid. The prognosis here is fairly hopeful, although guarded, as the indication is that the process is stationary and inactive.

Spinal Subarachnoid Block.—If the communication between the fluid in the spinal part and the cerebral part of the cerebrospinal canal is interrupted, the fluid below the block shows an increase in protein content and often discoloration. The cell count is not necessarily increased. The maneuver of compressing the internal jugular veins results in no increase in pressure from the spinal puncture. Causes of spinal subarachnoid block are tumors, ab-

secesses, and dislocations of the spine; intraspinal but extradural lesions, such as abscess or tumor; subdural tumors of the meninges; acute exudate as in suppurative or epidemic meningitis (in this case the blood may be due to inflammatory edema of the entire cord); chronic adhesions or cysts: in the cord itself, tumors, gumma, or syringomyelia.

Lateral Sinus Thrombosis.—Compression of the jugular vein on the side of the thrombosis fails to elevate the pressure of the spinal fluid, while pressure on the unaffected side does raise it.

Amyotrophic lateral sclerosis, chronic muscular atrophy, combined system disease as in pernicious anemia and most other degenerative diseases of the central nervous system, produces no characteristic fluid changes.

Multiple sclerosis, however, shows a quite characteristic set of findings. The pressure is normal, the protein content high (50-60 mg. per 100 c.c.), globulin is present in small amount, the cell count is increased slightly (15-30 cells), the gold sol shows a paretic curve, and the Wassermann is negative.

Radiculitis, such as herpes zoster, or nonspecific intercostal neuritis, etc., shows slight increase in cells and often marked increase in protein.

Cerebral Hemorrhage.—Bloody spinal fluid (provided error of technique is eliminated—sometimes the needle goes into a vertebral vein) indicates either bleeding of the pial vessels with or without brain damage from head injuries or spontaneous hemorrhage from some cerebral vessel, usually into the ventricles. In such cases the fluid may continue bloody or discolored for weeks. In arterial hemorrhage into the epidural space and venous hemorrhage into the subdural space, the fluid may remain clear but the pressure is increased. (Ayer.)

Chapter 24

TRANSUDATES AND EXUDATES

Fluids obtained from the pleural, pericardial, or peritoneal cavities are classified as *transudates* and *exudates*.

Transudates are the same as edema fluids. When the colloid osmotic pressure of the blood is decreased, as in nephrosis, an excess of fluid is forced out from the capillary vessels into the areolar connective tissue spaces and the serous cavities. When, as in the engagement of cardiac decomposition, there is an increase in intracapillary blood pressure the same thing occurs. (This is, of course, a very dogmatic statement of the cause of edema.)

Exudates are the result of inflammatory processes in the serous cavities—pleural effusion and empyema in the pleura, and tuberculous peritonitis and suppurative peritonitis in the peritoneum.

Fluids which accumulate as the result of neo-plastic implantation do not classify readily as either transudates or exudates.

Chylous fluid has an origin peculiar to itself.

Serotal fluids require separate consideration.

Transudates and exudates are classically differentiated as follows:

	TRANSUDATES	EXUDATES
<i>Color</i>	Light yellow	Yellow to turbid, to pussy
<i>Total Protein</i>	Less than 2.5 Gm. per 100 c.c.	Over 3 Gm. per 100 c.c.
<i>Specific Gravity</i>	Under 1.016	Over 1.016
<i>Cells</i>	Mesothelial cells predominate	Leucocytes, lymphocytes predominate

These are, however, not hard and fast distinctions. Paddock (*The Diagnostic Significance of Serous Fluids in Disease*, New England J. Med. 223: No. 25, December 19, 1940) found that in pleural effusion 90 per cent of cardiac fluids have a specific gravity of 1.016 or less and 90 per cent of tuberculous fluids have a specific gravity of 1.016 or more. In the ascitic fluid of cirrhosis 95 per cent of fluids was 1.015 or less. In nontuberculous infected pleural fluids, 31 per cent of specific gravity of 1.016 or less, and 34 per cent of cardiac peritoneal effusions had a specific gravity of 1.016 or more. Goldman, in a large series of cases, found that tuberculous effusions average a specific gravity of 1.023, malignant effusions 1.017, and transudates (cardionephritics) average 1.012.

Cytologic examination is of some interest. The fluid is centrifuged at high speed, and the sediment is stained with Wright's stain. Transudates give a rather brilliant variety of leucocytes, lymphocytes, monocytes, with the predominating cell the large mesothelial or endothelial cell undergoing fatty degeneration. Tuberculous fluids show monotonously lymphocytes. Suppurative exudates, of course, show neutrophile leucocytes almost exclusively.

By the method of Mandlebaum (*Proc. New York Path. Soc.* 1900) a better perspective of the cell content of these fluids can be obtained, and as

pointed out by Goldman (The Value of the Cytological Study of Effusions, Washington University Clinics, J. Mo. M. A. 26: No. 12, Dec., 1929).

The Mandlebaum method: 500 c.c. of liquid is placed in a large Erlenmeyer flask and allowed to stand overnight in an icebox. The supernatant fluid is decanted and the sediment, poured in a large 50 c.c. centrifuge, is centrifuged for at least twenty minutes. The supernatant fluid is again decanted and the sediment is hardened with 10 per cent formalin or Zenker's fluid for twenty-four hours. The fixed sediment is then treated as tissue by fixing, embedding, and sectioning.

Zemansky (Am. J. M. Sc. 175: 673, 1928) has shown that 60 per cent of carcinomatous effusions can be identified with accuracy. The pictures are often striking, as when a ring of metastatic bronchogenic cancer cells is seen.

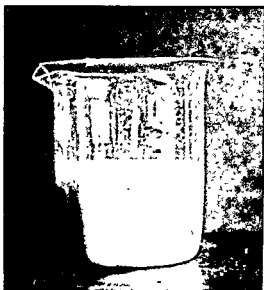


Fig. 72.—Chylous ascitic fluid, following metastatic plug caused by carcinoma of the stomach which blocked the receptaculum chyli.

Hemorrhagic pleural effusions (blood-tinged fluids are not characteristic of anything, nor is the finding of a few red cells microscopically) are due to malignant neoplasm in 65 per cent of cases. (Berliner: Hemorrhagic Pleural Effusion—An Analysis of 120 Cases, Ann. Int. Med. 14: No. 12, June, 1941.) The cause of hemorrhagic effusion in the nonmalignant cases was:

Miscellaneous inflammatory condition—sepsis, lobar pneumonia, bronchopneumonia, lung abscess, polyserositis—13 cases.

Tuberculosis—8 cases.

Pulmonary embolism—10 cases.

Leucemia—2 cases.

Hodgkin's disease—1 case.

Uremia associated with cardiac failure—1 case.

Undetermined causes—5 cases.

Pelvic fibromatous tumors—2 cases. This condition is of interest as a clinical syndrome established by the reports of Hoon (Fibromata of the Ovary, Surg., Gynec., and Obst. 36: 247, 1923), Salmon (Benign Pelvic Tumors Associated With Ascites and Pleural Effusion, J. Mt. Sinai Hosp. 1: 169, 1934), and Weld (Fibroma of the Ovary With Ascites and Pleural Effusion, New England J. Med. 218: 262, 1938). It consists of hemorrhagic pleural effusion in connection with benign pelvic fibromatous tumors. The effusions which are large disappear on removal of the pelvic tumors. They are possibly due to pulmonary embolism.

Chylous ascites or/and chylothorax is usually due to trauma, or more frequently to carcinoma of the stomach with a metastatic plug obstructing the thoracic duct and the receptaculum chyli. In one such case of my own the enlargement of the duct could be seen and palpated in the neck above the clavicle. Chylous fluids may also be due to nephritis, elephantiasis, new growth in the pleura, and enlarged glands.

Mucinous fluids, particularly from the peritoneal cavity, are apparently always associated with neoplasm. (McConnell: A Mucin-Containing Cyst of the Ovary, J. Med. Research 15: 105, 1909; Amberg: Mucin in the Pleural Fluid, Proc. Staff. Meet., Mayo Clin. 8: 181, 1933.)

Eosinophilic fluid occurs in such a large number of conditions that it cannot be said to have any specificity (see Cunningham: On the Origin of Free Cells of Serous Exudates, Am. J. Physiol. 59: 1, 1922).

Rheumatic effusions occur in a small fraction of cases of acute rheumatic fever (this does not mean pericardial fluid, which may almost be said to be an accompaniment of rheumatic fever) and have the properties of exudates—a high specific gravity, a tendency to bloodiness, presence of leucocytes, and a tendency to clot.

Pericardial fluids have not been very thoroughly investigated. Rheumatic effusions are commonest. Small effusions occur after coronary infarction. Tuberculous pericardial effusion occurs. When pericardial fluid is bloody, it usually means rupture or occlusion of a coronary vessel.

Chapter 25

IMMUNOLOGIC TESTS—BLOOD AND SKIN

Serologic tests that are of proved value in the diagnosis of disease*

Precipitation Tests:

Syphilis (Hinton, Kahn, Kline, Kolmer, and Eagle tests). These are very useful, since their ease of performance and high sensitivity make them ideal for the exclusion of syphilis.

Parasitic Infections. In trichiniasis and echinococcus disease, patients usually develop high titers of precipitins, as well as positive skin tests.

Pneumonia. Test for the presence of capsular polysaccharide in the blood and urine may be a valuable guide to prognosis and thus to therapy.

Spinal Fluid. A ring at the interface between spinal fluid and influenzal or meningococcal antiserum indicates meningitis with the corresponding organism.

Agglutination Tests:

Brucellosis. Agglutinins when present in titer of 1:80 or more are usually significant. The test is often negative in chronic infections or may be positive in normal subjects in endemic areas, particularly after acute infections.

Tularemia. Agglutinins nearly always rise, usually to high titers, and persist for many years.

Pneumonia. Agglutinins are considered by many to be the most satisfactory method for titrating antibodies.

Dysentery. Agglutinin titer seldom rises high. Occasionally an agglutination test is useful, e.g., when positive stool cultures are not obtained. Tests with the Stone and Shiga types are quite specific: the Flexner group is antigenically heterogeneous.

Salmonella Infections. In this group of infections, agglutination tests are of great value. The work of Kauffmann and White has revealed an extraordinary number of antigens in the group. A properly performed Widal test should include the various organisms that cause enteric fever in the local area. For New England this would be *Escherichia typhosa*, *S. schottmülleri* (paratyphoid B), *S. suispestifer*, *S. enteritidis*, and *S. aertrycke*. Two types of agglutination occur: the so called "H" or flagellar agglutination due to sensitization of the flagellar antigens, and the "O" or somatic agglutination caused by sensitization of the bacterial bodies. H agglutination is rapid (two hours at 55° C.), and large floccules are formed. O agglutination requires six to twelve hours at 55° C., and fine granular masses are formed. To detect O agglutinins either a nonmotile strain or a specially prepared suspension treated with heat to destroy the H antigen must be used. O agglutinins are very important in doubtful cases, because although a high H agglutinin titer may be produced by prophylactic vaccination or the anamnestic reaction, O agglutinins seldom appear above a titer of 1:80 except in response to infection, when they usually parallel H agglutinins.

Infectious Mononucleosis (heterophil agglutinin test). Serums in this disease agglutinate sheep and ox red blood cells in high titers. This may be associated with a false positive serologic test for syphilis.

*Taken by permission from an article by Charles A. Janeway, M.D., on Medical Progress in Bacteriology, New England M. & S. J. 224; No. 19, May 8, 1911.

Rickettsial Infections (Weil-Felix reaction). Patients recovering from rickettsial infections agglutinate certain *Proteus* strains. Typhus group agglutinates OX and OX 19, tsutsugamushi group OX-K, spotted fever group both strains.

Complement-Fixation Tests:

Syphilis (Wassermann test).

Gonococcus Infections. The gonococcus complement fixation test is much abused. Antibodies appear only infrequently in response to local genitourinary infections, but do appear in a high percentage of cases of endocarditis and arthritis. The test is useless in following the course of local gonorrhea, but very useful in the differential diagnosis of arthritis and bacterial endocarditis.

Positive serologic tests are interpreted "on the assumption that the development of antibodies against a particular infectious agent or some of its products is evidence that the patient has suffered from an infection due to that particular agent. The assumption is based on two premises: that antibodies are specific and that their formation is always induced by a specific stimulus. These premises have a solid immunologic foundation because specificity is the most striking characteristic of serologic reactions." (Janeway.)

The report of a positive serologic test for any of the diseases mentioned in the foregoing list is therefore among the most reliable and immutable diagnostic reports the clinician considers.

Serologic Tests for Syphilis

The original Wassermann test has been modified by a number of workers so that the clinician now finds reports of Kahn, Hinton, Kline, Kolmer, and Eagle tests from various laboratories. Moore and Eagle (*The Confusing Multiplicity of Serologic Tests for Syphilis*, J. A. M. A. 117: No. 4, July 26, 1941) have logically protested against this practice and suggest that the results of laboratory findings be reported on an over-all composite basis as "Serologic Tests for Syphilis—Positive, Doubtful or Negative" (S.T.S.). The reverse of the report sheet should carry a statement as to the results obtained with individual tests, on which the over-all report is based, so that no information of diagnostic importance is withheld from the clinician.

Two forms of serologic tests are used for syphilis—complement-fixation tests and flocculation tests. The complement-fixation tests consist essentially of incubating the blood serum of the patient with a suspension of lipoids (antigen) and with complement. This fixation is a quantitative reaction which depends upon the antigen-antibody union. The fixation of complement is an invisible reaction, and it is therefore necessary to introduce an indicator—a hemolytic system usually in the form of antishoop hemolysis and sheep red corpuscles. When syphilitic reagents are present, they combine with the antigen, fixing it, and no hemolysis of the sheep cells occurs; this constitutes a positive test. The original Wassermann is a complement-fixation test. The most used modifications—the Kolmer and the Eagle tests—are designed to be more sensitive and more specific than the original.

Flocculation tests depend upon the phenomenon that when a properly prepared lipoid extract of beef heart is mixed in certain proportion with a syph-

ilitic serum, a precipitate is formed. Flocculation tests do not require complement and a hemolytic system, and they take less time to perform. They are considered more sensitive than the complement-fixation tests. The ones commonly in use in the United States and Canada are the Kahn, the Kline, the Hinton, and the Eagle tests. (For a detailed comparison of the various tests see Supp. 1, Venereal Disease Information, Washington, D. C., 1935; and Supp. 9, Venereal Disease Information, Washington, D. C., 1939.)

As to the relative value of the two tests, I believe the feeling of experienced syphilographers is well expressed by Dr. John H. Stokes (*Modern Clinical Syphilology*, W. B. Saunders Co., 1934): "The clinician must concede the value of these researches (flocculation tests) as an effort to simplify and render more available the laboratory tests for syphilis. The basis for their efficiency has, however, been the Wassermann test, and to a properly performed Wassermann test they remain thus far subsidiary and on the whole less trustworthy."

The clinician, in other words, in all doubtful cases will wish a report on a flocculation test and for confirmation a report on a complement-fixation test.

Most of the reports we have on the value of serologic tests for syphilis are based on the Wassermann test, but where comparative data are available they are supported by the results from the various modifications of complement-fixation and precipitation tests. We will, therefore, record them as Serologic Tests for Syphilis.

PRIMARY SYPHILIS

DURATION OF CHANCERE	PERCENTAGE, POSITIVE S.T.S.
1-10 days	36
10-20 days	64
20-30 days	70
over 40 days	100

(Dark-field examination of scrapings from the chancre should, of course, supplement the serologic tests. Or rather, the other way about—the serologic tests supplement the dark-field examination. In chancres 1 to 10 days old, dark-field examination is positive in 94 per cent of cases; in chancres 10 to 20 days old, in 53 per cent of cases; in chancres over 40 days old in 30 per cent of cases.)

"The highest positive efficiency of the Wassermann test is reached in a period extending from about three weeks after the appearance of the chancre to the height of secondary manifestations covering roughly about six months. From this pinnacle of efficiency the proportion of positive Wassermann results obtained from the blood gradually declines." (Stokes.)

SECONDARY STAGE

In a series of 53 consecutive cases examined by Moursand (*The Practical Value of the Wassermann Reaction*, Texas State J. Med., March, 1917) in the secondary stage of syphilis, all gave positive reaction. The percentages of positive reactions in the secondary stages, as given by various observers, vary from 92 to 100 per cent.

LATE SYPHILIS

Des Brisay* compiled the following table showing percentage of positive serologic tests for types of untreated syphilis:

	PER CENT
Visceral	100
Latent	93
Cardiovascular	85
Osseous	84
Cutaneous	81
Mucous membrane	80
Neurosyphilis (blood reaction)	41

CONGENITAL SYPHILIS

Kolmer states that in manifest untreated congenital syphilis of children one year or over in age, the serologic test is positive in 97 to 100 per cent of cases.

From all this evidence it becomes manifest that a positive serologic report is of the greatest significance. Some clinical conditions have been reported to give a nonspecific positive reaction. In yaws there is no question that a positive test is obtainable about as often as in syphilis itself, but yaws, as a clinical confusion, does not enter into the calculations of clinicians in temperate climates. Other conditions reported as giving false positive reactions are: leprosy, tuberculosis, the acute exanthemata, pneumonia, septicemia, trypanosomiasis, relapsing fever, general anesthesia, advanced carcinosis (especially hepatic), pernicious anemia, malaria, pregnancy, Weil's disease, diabetes, spirochetal (Vincent's) infection of the lungs, and systemic mycotic infections. All of these are quite debatable, although the careful clinician will wish to check up on the test in their presence.

Negative Serologic Tests for Syphilis

In suspected secondary syphilis, in the efflorescent stage, repeated negative serologic tests have great significance—sufficient, according to Stokes, practically to rule out syphilis. After that the significance of a negative reaction becomes less and less. "From one-fifth to one-half the syphilis which the average clinician sees will present itself with negative Wassermann credentials, and will have to be recognized by other means or go undetected. Patients have gone to their doom with a record of years of negative tests. Many of the gravest complications of the disease may appear and progress to fatal degenerations, especially in the nervous and the vascular systems, with never a hint from the blood Wassermann reaction, and persistently negative tests may reverse to subsequently irreversible positives without an apparent cause." (Stokes.)

Doubtful or plus-minus reactions, when no treatment has been instituted, should be regarded with wholesome suspicion. In their presence one is thrown

*Stokes, J. H., and Des Brisay, H. A.: Canadian M. A. J., 14: 715-718, Aug., 1924.

back on the arduous and time-consuming task of being a clinician. But, after all, the diagnosis of syphilis is not exactly the place for the government doctor or any other short-cut artist.

PROVOCATIVE WASSERMANN

In 1910 Gennerich announced that a negative Wassermann test could be re-actuated by a preliminary small intravenous dose of arsphenamine. This procedure has taken its place as a routine part of the diagnosis of syphilis in doubtful cases. There is no doubt of its validity when positive: the blood serum and spinal fluid, which have been previously negative, become positive after a stirring up of the disease process by specific treatment with one of the arsphenamine preparations (or the Swift-Ellis treatment). The immunologic process involved is not understood. The procedure adds approximately 18 per cent to the average proportion of positive serologic tests. It must be interpreted just as any serologic test for syphilis: there are positives, negatives, and doubtfuls reported. A negative provocative test does not mean cured syphilis. The reaction is transitory: it is recommended that seven daily serologic tests be made following a dose of 0.3 grams of arsphenamine intravenously.

Effect of Treatment.—Previously positive serologic tests become negative under treatment. Such a change is a good index of the effectiveness of treatment, but not necessarily an index of cure. The first symptom of relapse is likely to be a return of a positive serologic test for syphilis. In patients who come under the clinician's care late in the course of the disease, have had inadequate or no treatment in the early stages, and have positive serologic tests, it is likely to remain positive no matter how vigorous the treatment.

Agglutination Tests

Agglutination tests are highly reliable and serviceable immunologic tests for typhoid, paratyphoid, dysentery, typhus, undulant fever, tularemia, plague, and cholera. They should not, however, displace bacteriologic procedures for the isolation and identification of the specific agent if possible. Agglutinins are formed probably in the reticulo-endothelial cells.

Typhoid and Paratyphoid Fever.—The "Widal" test is practically 100 per cent reliable if positive. It means active typhoid or paratyphoid fever (or both), or past infection, or a previous vaccination with typhoid or paratyphoid bacilli.

It is said that in regions where typhoid is endemic, agglutinins may be found in a certain proportion of the population. This is, of course, merely the result of vaccination via the digestive tract.

The only exception noted to the statement of the significance of a positive Widal is what is called the anamnestic phenomenon, by which is meant the formation of agglutinins in persons with infections other than typhoid. A fever may awaken the agglutination response and advance the titer in one who has been vaccinated.

The strength of the titer varies in all cases, but in general, of course, active infection is accompanied by a more concentrated titer. But this is not

a hard and fast rule. In active typhoid infection, agglutination begins in seven to ten days after the onset of illness. A titer of 1 to 100 or more is strong evidence of active infection. The titer rises to a maximum at three to five weeks.

Paratyphoid fever gives an agglutination in dilutions of 1 to 40 and up, in the absence of previous inoculation. The antigen response is, however, weaker in paratyphoid than in typhoid, and cultural methods should always be employed for diagnosis.

Undulant Fever—Brucellosis.—Many persons in a community where dairy herds are widely contaminated with *Brucella*, according to the studies of Angle and others, give a positive agglutination test in dilutions of 1 to 100. They also give a positive skin test. The titer is, therefore, of importance in interpretation. Agglutination occurs in 20 to 40 days after the onset of illness, sometimes as early as the end of the second week. A titer of 1 to 20 at first and increasing to 1 to 100 may be considered positive evidence of an acute infection, in the absence of previous infection or previous known positive agglutination tests of the blood. Caution must be used in interpreting reactions in veterinarians, slaughterhouse employees, and in the population of a dairy country. Making a *Brucella* skin test will eliminate the significance of an agglutination test. Little significance applies to positive tests, when it is hoped to prove that such infections as cholecystitis and arthritis are of *Brucella* origin: recovery of the organism on culture is the only positive evidence under these circumstances. In making agglutination tests, strains of both *B. abortus* and *B. melitensis* should be used.

Tularemia.—Agglutination appears after the first week of the disease, and increases in concentration up to the seventh or eighth week. Titers of 1 to 1,000 are not unusual. The length of time agglutinins persist in the blood is variable. Usually at the end of a year, agglutination may occur at a dilution of 1 to 1,000. Francis and Evans had a patient whose serum agglutinated at a dilution of 1 to 20 at the end of eighteen years.

Bacillary Dysentery.—Agglutinins appear during the second week. The titer is not high. Agglutinins for some bacilli in the group occur in many normal persons, in an endemic community. A rising titer against the Shiga bacillus in a dilution of 1 to 40 may be considered positive evidence of active infection. Upon the termination of the disease the agglutinins tend to disappear from the blood. (Wahlin in Kracke and Parker's *Textbook of Clinical Pathology*, Baltimore, 1940, Williams & Williams Co.)

Precipitin tests are positive in trichinosis and echinococcus disease. In trichinosis the test is used in a dilution of 1 to 20 or 1 to 100. It persists for a year and is negative five to seven years after infection. Identification of the parasite in muscle biopsy is more conclusive, but such findings occur in only 50 per cent of cases, at most.

Skin Tests

The skin possesses peculiar immunologic properties. Injections of proteins and antigens into the true skin, the dermis, result in inflammatory re-

actions which indicate a state of hypersensitiveness or absence of immunization of the entire body toward the antigen. The diseases in which these reactions are of clinical value are:

IMMEDIATE REACTIONS.

Allergy, atopy, asthma, hay fever, food sensitivity, urticaria, etc. The substances used for injection are pollens, food proteins, serum, etc.

Helminth infestations (trichinosis, echinococcus). The substance used as an antigen is extract of the worms.

DELAYED REACTION:

Tuberculosis.—The antigen used is old tuberculin or P.P.D. (purified protein derivative).

Brucellosis.—The antigen used is *Brucella* vaccine.

Tularemia.—The antigen used is detoxified *Past. tularensis* vaccine.

In all three of the above the test remains positive for years after the infection, whether that be clinical or subclinical. The value of the diagnosis, therefore, is in inverse ratio to the frequency of exposure to the infection. In tuberculosis, therefore, a negative test is of more significance than a positive.

Lymphogranuloma Inguinale.—Frei test. The antigen used is inactivated bubo pus, inactivated infected mouse brain, or inactivated infected chick embryo extract, the last being recommended as most satisfactory.

Schick Test for Diphtheria.—The antigen used is diphtheria culture filtrate heated to inactivate toxin.

Dick Test for Scarlet Fever.—The antigen used is culture filtrate heated to inactivate toxin. A variant, or rather the opposite, is the Schultz-Charlton test, in which scarlet fever antitoxin is injected into the skin of a patient with a scarlatiniform rash; if the site of the injection becomes blanched within twelve hours it is true scarlatina.

Skin tests for the detection of allergy to pollens, animal emanations, food, dusts, etc., are entirely specific and, in fact, form part of the essential picture of allergy. The skin wheal which results from the intradermal scratch or intracutaneous injection of an offending allergen appears in within fifteen to thirty minutes and assumes an irregular shape like the outline of an amoeba with pseudopods, and a large area of red inflammatory reaction outside the wheal, subjective sensations of itching, and warmth appear. The reaction may be delayed and not appear for eight hours, but this is unusual in allergic work. A control injection of a nonoffending substance is used, and reactions are rated comparatively to it: when the wheal is about the same size, round and small, as the control, the result is negative. Positive reactions are reported as 1, 2, 3, or 4+.

Does a negative reaction rule out sensitiveness to the allergen tested? In my opinion, it does. A few years ago when they had not proved everything that they had set out to prove, allergists began to say that after all a negative skin reaction did not really mean that the individual was not sensitive. That if the history revealed a sensitiveness, the skin test could be ignored if negative. In doing this, they turned their backs on the original principle of allergy, namely, that the skin was the sensitive barometer of the existence of

an allergy. In fact, the skin tests were about the only thing that gave allergy any scientific standing: their vaccine therapy rests on a very shaky theoretical superstructure. When allergists abandoned the idea that skin reactions can be negative while the allergic state still exists, they vitiated everything that commanded respect from the profession. Such statements have a strong commercial appeal, but that is all.

Tuberculin.—"Tuberculin is the most exact and finest reagent for proving the existence of a tuberculous deposit in the living organism." So wrote Bandelier and Roepke in 1913, and the statement still stands as valid. In fact, the exactness and fineness of the reactivity of tuberculin is its very liability for practical diagnosis.

The general tuberculin reaction as originally employed by Koch (the subcutaneous injection of about 0.00001 c.c. old tuberculin which is followed by a febrile reaction if positive) has been, so far as I know, universally abandoned. It was potentially dangerous, and the interpretation of results confusing. The cutaneous test of von Pirquet, which is practically a scratch test, is too sensitive for practical work.

The methods used are the intracutaneous test and the patch test.

Intracutaneous Test (Mantoux).—Old tuberculin (O.T.) or, preferably, purified protein derivative (P.P.D.), which is the active principle of O.T., is used. P.P.D. is prepared in tablets containing 0.0002 and 0.05 mg., respectively. These are dissolved in 1.0 c.c. of buffered saline solution. The test is made by injecting 0.1 c.c. of the first strength into the skin of the forearm. At the end of forty-eight hours the test is judged; if negative, 0.1 c.c. of the second strength is injected in the same way, and the result read at the end of forty-eight hours. A positive test consists of redness and edema, the edema being considered more important than the redness. The National Tuberculosis Association has set up the following standards:

One plus—redness and edema 5-10 mm. in diameter.

Two plus—10-20 mm. in diameter.

Three plus—marked redness and edema exceeding 20 mm. in diameter.

Four plus—redness, edema, and central necrosis.

Doubtful—slight redness and edema 5 mm. or less in diameter.

Interpretation is best made by palpation, according to Myers (*The Detection of Tuberculous Infection*, J. A. M. A. 112: No. 19, May 13, 1939). In the absence of induration or edema no reaction should be recorded.

In cases of overwhelming infection, as in miliary tuberculosis, the test is likely to be negative. A positive test indicates only that infection with the tubercle bacillus has occurred sometime in the patient's life. The more positive the test, the greater likelihood that the process is active. In adults, the percentage of positives is so high that the test has no value. In persons who have lived in crowded quarters on low economic levels, positive tests are more frequent than in those of good economic environment. Thus Lees and Myers found that University of Minnesota students, aged sixteen to twenty-two years, gave 32 per cent positives and those over twenty-three years of age, 57 per cent positives. But tuberculin tests have a limited usefulness confined to the survey

of groups of school children. The percentage of positives rises as age advances. Thus in a large group of children (city-bred) the following results were obtained with the Mantoux test:

AGE	POSITIVE REACTORS TO TUBERCULIN (%)
0-1 year	20
1 year	23
2 years	26
3 years	28
4 years	29
5 years	31
6 years	34
7 years	34
8 years	28

In a group of college students (largely from agricultural communities) Stiehm found:

AGE	POSITIVE REACTORS TO TUBERCULIN (%)
16 years	19.4
17 years	20.3
18 years	21.2
21 years	32.0
25 years	50.0
45-50 years	90.6

The *patch test*, introduced in 1937 by Vollmer and Goldberger, consists of placing on the intact skin a strip of adhesive tape on which has been placed two small squares of filter paper saturated with old tuberculin, with a control square between. The strip is removed in 48 hours, and the reaction read 48 hours later (96 hours after application). A positive reaction consists of a red edematous area which may show vesicular or follicular elevations. The advantages of this test in pediatric practice with infants is obvious. It seems to be quite as reliable as the Mantoux test. Pearse, Fried, and Glover (J. A. M. A. 114: No. 3, Jan. 20, 1940) conclude:

"Seven hundred and twelve school children were given both the tuberculin patch test and the Mantoux test, first and second strength purified protein derivative.

"Six hundred and sixteen had either both tests positive or both negative, the percentage correlation between the two tests in this series being 87 plus.

"Sixty-seven had positive patch and negative Mantoux tests.

"Twenty-one had positive Mantoux and negative patch tests.

"Conclusions: The tuberculin patch test has a high degree of correlation with the Mantoux test and appears to give 7 per cent more positives than the Mantoux.

"We can conclude that the tuberculin patch test is as reliable as the Mantoux. Its ease of application and nontraumatizing character make it superior to the Mantoux test in other ways.

"We believe for these reasons that the tuberculin patch test is the method of choice in large scale tuberculin testing, especially for children."

Schick Test.—The Schick test is made by injecting intradermally 0.1 c.c. of a solution of standardized diphtheria toxin in normal saline, diluted so that

0.1 c.c. of the solution contains $\frac{1}{50}$ of the minimum lethal dose (M.L.D.) for a guinea pig. The reaction is read in 24 to 36 hours. A positive consists of a central area of induration surrounded by redness which measures at least 1 cm. in diameter. This means that the individual's blood contains less than $\frac{1}{30}$ unit of antitoxin per cubic centimeter, which is insufficient to protect against diphtheria.

Brucella Skin Test.—One-tenth cubic centimeter of antigen is injected intradermally. The reaction is read 48 hours later, a positive consisting of redness, edema, and induration. It has a high degree of specificity and sensitiveness.

Frei Test.—*Lymphogranuloma inguinale* is an infectious disease, caused by a filtrable virus, usually transmitted by sexual intercourse. It is characterized by an insignificant primary lesion, followed by adenitis of the inguinal lymph nodes which progresses to periadenitis involving the skin, with softening and ulceration. This is followed by cicatrization involving the vagina and rectum. Since the condition may simulate ulcerative colitis, it is necessary to use specific diagnostic procedures of identification of the virus in the mouse brain through the presence of Donovan bodies and also the Frei skin test. The best antigen to use for the skin test is extract of the infected yolk sac of the developing chick embryo (see Sulkin, Fletcher, Huber and Reh: *The Frei Test for Lymphogranuloma Venereum*, J. A. M. A. 110: No. 24, June 14, 1941), 0.1 c.c. of the antigen is injected intradermally. The reaction is read within 48 to 96 hours. A typical positive reaction consists of an elevated reddened central papule surrounded by an erythematous areola. In the Negro, in which racial group the disease occurs most frequently, the erythematous areola is not easy to discern. The test has a high degree of positive and negative value.

Bacteriologic Methods

Blood Cultures.—Blood cultures are of diagnostic value in typhoid, paratyphoid, brucellosis, bacterial endocarditis, and by animal inoculation in tetanus, *B. welchii* infection and botulinus infection. A positive culture is almost always significant. Contamination occurs and may vitiate conclusions, and for this reason it is well for the clinician to inquire whether the inoculation was made directly at the bedside.

Subacute bacterial endocarditis is the condition in which blood culture is most likely to be unsatisfactory. So often the clinician requires, in the absence of petechiae, a positive blood culture which is not forthcoming. Almost equally often he gets a positive report that he does not know what to do with. Laboratory technique is, in this field, of the greatest importance. Nonhemolytic streptococci are responsible in 95 per cent of cases. (Kinsella.)

Smear examination, cultures from discharges and skin lesions do not often concern the internist. This especially applies to eye, ear, nose, throat, and urethral discharges. The dark-field examination of suspicious sores for the *Treponema pallidum* will be accepted by the clinician as positive or negative on the basis of the integrity of the laboratory making the report. The examination of skin scrapings for fungi belongs in the field of the dermatologist.

Chapter 26

X-RAY DIAGNOSIS

I. X-RAY EXAMINATION OF THE BONES AND JOINTS

A. Diseases of Bones:

1. The four common bone diseases:
Infection, Tuberculosis, Syphilis, Neoplasm.
2. Endocrine and Metabolic Changes in Bone.
3. Miscellaneous Bone Diseases:
Aseptic necrosing bone disease.
4. Bone Disease in Blood Disorders.
5. Congenital and Anatomic Anomalies:
Spina bifida. Cervical rib.

B. Diseases of the Joints:

1. Acute Arthritis.
2. Chronic Arthritis.
3. X-ray Aspects of Lumbago.
4. Miscellaneous Causes of Pain Around Joints.

C. Muscles, Bursae and Veins.

The internist will be called upon to interpret plates of the bones and joints which are affected in the course of general diseases. These will be reviewed here in only such detail as the subject warrants.

The four great common bone (as distinct from joint) diseases are osteomyelitis, tuberculosis, syphilis, and bone tumor. In recognizing and differentiating them certain general principles are helpful.

1. THE CHARACTER OF THE PATHOLOGIC PROCESS.—*Osteomyelitis and syphilis are constructive, tuberculosis and tumor are destructive.* This principle was taught me many years ago and I can testify to its continuous usefulness over a clinical experience of more than thirty years.

The typical plate of osteomyelitis shows bony overgrowth and sequestra. It also, of course, shows destruction, but production is paramount. The typical picture of syphilis is the dense bony overgrowth of saber tibia. In tuberculosis there are destruction and absorption of bone, decalcification either in spots or over large areas; "reduced density," as the interpretations say. The plate showing tuberculosis of the bone often looks like a bad plate, because of lack of calcium salts. Most tumors destroy bone tissue: some, such as osteogenetic sarcoma, both destroy and construct bone.

2. THE LOCATION OR POINT OF ORIGIN OF THE PROCESS.—

Diseases on the bone may originate in:

- a. The periosteum—example, periosteal sarcoma.
- b. The cortex—example, syphilis.
- c. The medullary canal—example, osteomyelitis.
- d. The epiphysis—example, tuberculosis.
- e. Articular surface—example, pyogenic arthritis. (After Sante.)

DISEASES OF BONES

Tuberculosis.—In tuberculosis the bone alone is less often affected than the bone and joint together. Tuberculosis in the skeleton begins as an epiphysitis, which is a destructive process in the synovia, or subarticular region of



Fig. 73.—Tuberculosis of the spine.

the epiphysis and spreads to involve the joint. It is largely a disease of childhood. In tuberculosis of the bones, the metacarpals, metatarsals, and phalanges are most frequently affected. Any of the long bones may, however, be affected,

clavicle, tibia, and fibula following the hand bones in frequency. Primary infection of the body of a vertebra is a common lesion in childhood. Tuberculosis of the spine is usually confined to the bodies of the vertebrae, seldom involving the transverse or spinous processes. This results in the breaking

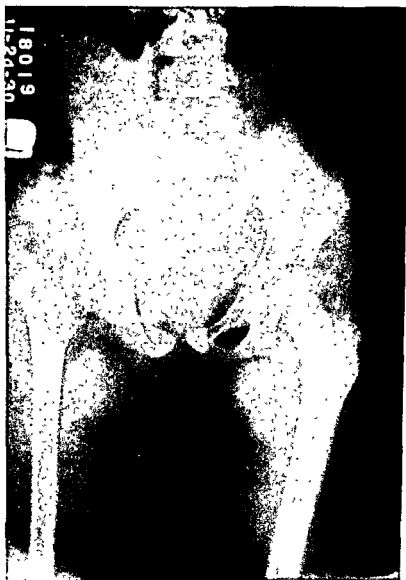


Fig. 74.—Tuberculosis of the hip.

down of one to several adjacent vertebrae with little or no new bone formation. Destruction of the bony cortex adjacent to the intervertebral disk produces secondary changes which lead to a narrowing of the intervertebral space. Collapse of the bodies of the vertebrae and preservation of the intervertebral shadows is indicative of malignancy rather than tuberculosis.

Tuberculous arthritis affects most often the hip and knee. The first stage is an effusion into the joint, causing a hazy appearance in the x-ray film. Then follows bone atrophy from disuse, then there is destruction of cartilage and bone. Lastly there are attempts at repair.

Syphilis.—Congenital syphilis can give a bewildering variety of bony and articular lesions, duplicating nearly all those seen in the acquired form, even to Charcot joints. The student is advised to consult the comprehensive article by Stafford McLean (*Am. J. Dis. Children* 41: 130, Jan., 1931) and the chapter in Dennie and Pakula's splendid monograph (*Congenital Syphilis*, Lea & Febiger, 1940).

In prenatal lesions the predominant lesion is osteochondritis (90 per cent of all cases); then periostitis with exaggerated periosteal bone production (70 per cent); osteomyelitis (46 per cent) and osteitis (7 per cent).

McLean considers the following types of x-ray changes practically pathognomonic of congenital syphilis:

1. Well-defined saw-tooth metaphyses in well-calcified bones.
2. Deep zones (in the longitudinal axis) of the submetaphyseal rarefaction.
3. Multiple "separation of epiphyses" with or without impaction of bones which are not rachitic.
4. Bilateral symmetrical osteomyelitis of the proximal mesial aspects of the tibiae.
5. Multiple circumscribed osteomyelitis of the long bones. Patchy areas of rarefaction.
6. Multiple longitudinal areas of rarefaction (osteomyelitis) in the shafts of the long bones sometimes resulting in fractures.
7. Destructive lesions at the mesial or lateral parts of the metaphyses (foci of rarefaction).
8. Multiple areas of cortical destruction generally seen within a centimeter of the ends of the bones.
9. Double zone of rarefaction at ends of bones.
10. Localized periosteal cloaking occurring in more than one bone.

Clutton's Joints (described by Clutton in 1886).—There is a bilateral symmetrical synovitis and periarticular infiltration. Knees and elbows are the usual sites. Sometimes a gumma of the bursa is the real pathologic condition. They are regularly associated with interstitial keratitis. Parrot's pseudoparalysis is due to a separation of the epiphyses, usually from rough handling of the infant.

Syphilitic Dactylitis.—Chassaignac, in 1859 (*Clinique Européenne*, p. 238). Nelaton, in 1860 (*Gaz. d. Hôp.*, p. 105), and Lüche, in 1866 (*Berliner klin. Wehnschr.* Nos. 50 and 51), published accounts of this form, but it was R. W. Taylor's paper in the *American Journal of Syphilography and Dermatology* (January, 1871) that gave the first comprehensive account: Taylor had been graduated only three years at the time of its publication.

Dactylitis syphilitica occurs as a rule in children from six months to two years of age. It attacks the short round bones of the hands or feet—the car-

pals or metacarpals or first phalanges; the terminal phalanges are seldom involved. Usually only one bone is affected. The affected part shows a cylindrical swelling, and is painful and red. In the x-ray plate the shaft of the bone is larger than the bones on either side. There are usually areas of rarefaction and a lattice-like arrangement due to the osteomyelitis which usually accompanies this form of bony syphilis. Sometimes it has the appearance of a smooth bone cyst. Tuberculous dactylitis may present some difficulty in differential diagnosis; so far as the x-ray evidence is concerned the tuberculous form occurs in older children, involves the joint, and is more destructive. Syphilitic dactylitis occurs also in adults in acquired syphilis.

Acquired Syphilis.—Wile and Sinear, in a survey of 165 consecutive and unselected cases of syphilis, found bone or joint lesions in 60 per cent. The typical bony lesion of acquired syphilis is the saber tibia, a dense overgrowth of bone demonstrating one generalization, namely, that syphilis is constructive in its action, resulting in overcalcification. The lesions are usually tertiary. The hyperostosis is usually laid down along the periphery and to a less degree in the medullary cavity. The only exception to the "constructive" rule is the formation of a gumma, but this is fairly rare in bone (the sternum curiously being a favorite site). "The tibia and the shoulder girdle stand out as the two bony structures detailed examination of which should never be overlooked in a general examination where syphilis is to be detected." (Stokes—*Modern Clinical Syphilology*, W. B. Saunders, 1935.) The shoulder girdle includes the ribs. The cranium is really the most frequent site (42 per cent). (Tibia, 26 per cent.) Pathologically periostitis and osteomyelitis are the lesions. Cranial periostitis may account for many syphilitic headaches.

Joint involvement per se is rare in syphilis, with knee, ankle, and wrist leading in frequency in the order named—spine and fingers next. There is usually destruction of the joint surfaces and fluid present. The joint is often indolent and any comparative freedom of movement of a joint should suggest syphilis. X-ray plates may be completely negative.

Charcot's joint is a special form of arthritis associated with nervous syphilis, usually tabes. I borrow the following excellent description from Samuel C. Waldenberg (*Urol. & Cutan. Rev.*, 252, April, 1941).

"The soft parts are tremendously enlarged about the involved joint. There is evidence of destruction of the articular surfaces. This amounts to a complete disorganization of the joints, and in advanced cases, large irregular masses of bone and calcified material are scattered through the joint. This appearance has led roentgenologists to refer often to these joints with the descriptive term of 'bag of bones.' The bone is increased in density rather than rarefied. Some writers on this subject call attention to a diminution of muscle tone without the evidence of weakness. . . .

"Roentgenologically, the physical findings change with the progress of the disease. X-ray findings include swelling and increased density of the soft tissues, excess fluid in the joint, and tissue changes in the bone itself. Erosion of the bearing surface, the production of new bone, pathological fractures, loose bodies in the joint, calcareous debris in the periarticular tissues. Subluxations or dislocations of the articular surface are also to be seen.

"According to Blaine, early changes may at times be difficult to detect or to be differentiated from an early arthritis. According to Carman, there

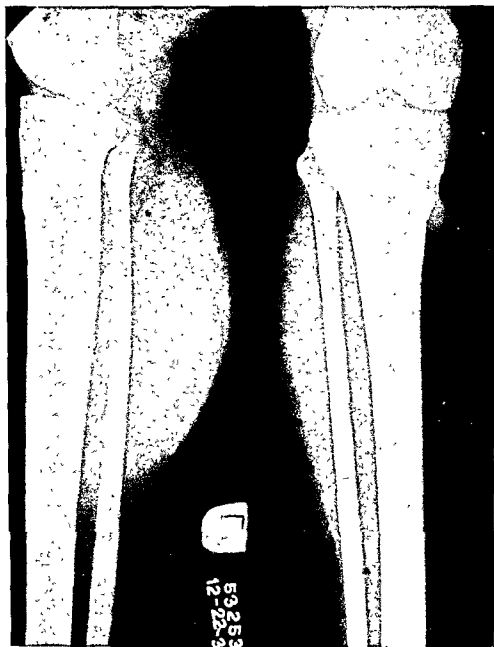


Fig. 75.—Syphills of the tibia.

may be included extensive proliferating and destructive processes which run a parallel course leading to extracapsular ossifications. Fluid in the joint, villi in the cavity, subluxations, osteophytes, increased circumference of the bones in the epiphyseal region and spontaneous fractures will also be found.

"Key states that tabetic symptoms are largely of the lower cord type; and reasoning from this observation, it is fair to assume that tabetics in whom the lower cord symptoms are marked will be more liable to develop Charcot 'joints.' "

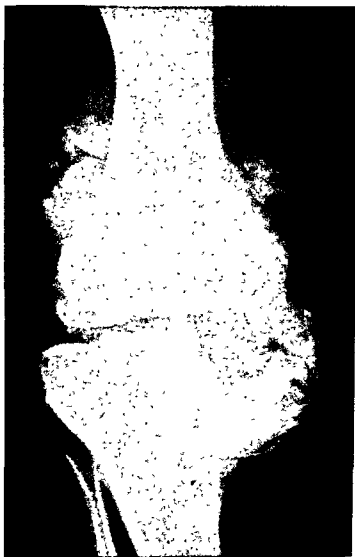


Fig. 76.—Charcot's joint.

Osteomyelitis.—Pyogenic osteomyelitis is a condition about which the general internist makes as many mistakes of omission as of nearly any other single disease which happens to fall under his care.

I have seen cases which have been treated for long periods for acute articular rheumatism, hypertrophic arthritis, sciatica, tuberculosis and nearly everything else that suggests bone or joint disease.



Fig. 77.—Osteomyelitis of the fibula with sequestra.

The case that haunts my memory is one that I inherited on a general hospital service. A young man had been lying for three months with a pain in his hip with the diagnosis of *acute articular rheumatism* and treatment by salicylates. The interne told me the diagnosis was made largely because of a

heart murmur. I examined his heart and said, "But he hasn't got a heart murmur. Where is the x-ray?" None had been taken. When produced it showed an extensive osteomyelitis of the femur which had gone without diagnosis for three months, even in spite of the plain history of a preceding infection of the skin of the toe. The end result was amputation at the hip, and the reason the event haunts me is that this young man comes to see me every now and then, on crutches, to tell me how grateful he is to everybody.

Osteomyelitis is an infection of the bone which reaches it from the blood stream, almost always from a *primary focus in the skin*. Most cases occur in childhood, but 5 per cent have an onset in adult life.

Pathologically the infection usually begins in the metaphysis. There is inflammation, edema, necrosis, leucocytic infiltration, pus formation, and new bone formation, and sequestra formation. The exudate spreads along the medullary canal for varying distances, penetrating the cortex here and there and accumulating beneath the periosteum. The infection usually becomes localized in almost two weeks, but this rule may have many exceptions.

The x-ray plates show the sequestra which are denser than the living bone, with irregular outlines and widely growing spongy bone outside the shaft of the original bone. These are relatively late changes. Few changes can be seen on the plate before the tenth day. The first changes seen are dependent upon the absorption of dead bone and the formation of new bone. The density of the living bone increases as the disease heals.

Secondary osteomyelitis may occur from the direct extension of infection from the soft parts, from infection from an adjacent joint, or from infection from a foreign body. In such cases there is no such tendency to spread as in primary osteomyelitis, but tends to remain localized. Sequestra seldom form and are small.

OTHER INFECTIONS IN BONE

Actinomycosis.—Due to direct extension from the soft parts, the usual sites are the jawbone, the ribs, and the lumbar spine and sacrum. Necrosis and absorption are more marked than new bone formation—4 cases of spinal involvement reported by Simpson and McIntosh were all reported as tuberculosis of the spine before necropsy.

Blastomycosis may extend to the bone from adjacent skin involvement. Systemic blastomycosis may affect bones anywhere. The spine is often involved in this form. The lesions are very destructive with hardly any attempt at bony repair. There is nothing characteristic about their appearance. Sporotrichosis, yaws, and echinococcus affect the bones, but all are so rare in North America as to be negligible.

Tumors of the bone seldom come into the province of the internist. A brief description of the common forms follows.

BENIGN TUMORS.—**Osteoma.**—These bony overgrowths are readily recognized in the x-ray plate as projections from the long bones. When one occurs in the frontal sinus or other nasal sinuses, it is not so easily detected; these appear as unencircumscribed, rounded, or nodular prominences on or within the bone. The shadows are dense.

Cartilaginous Osteomata or Exostosis.—These occur in the ends of the shafts of the long bones. They may be single or multiple.

Chondromata are most frequently encountered in the phalanges of the hands and in the ribs, rarely in the long bones of the extremities.

Benign giant cell tumor usually occurs in adults over fifty, but may occur in children. It is most frequently seen in the lower end of the femur, but may occur anywhere. It appears on the x-ray plate as a *localized area of reduced density*.

Chondrodysplasia.—This is an accumulation during the growing period of hyaline cartilage in the ends of the shafts of the long bones of one or two extremities. It is a disturbance of endochondral classification and is more of a *developmental anomaly than a neoplastic process*.

Hemangioma of Bone.—This is most frequent in the dorsal vertebrae and flat bones. The bones of the extremities are only occasionally involved. The peculiar alteration in the bony architecture renders them easily detected on the x-ray plate. In the vertebrae the vertical trabeculations are quite prominent, being wider than normal and separated by wide spaces. *Cavernous spaces* can be made out in the bone.

The jaw is the seat of several forms of benign tumor, dentigerous cysts, adamantinoma, and epulis. The last named produces bone destruction.

MALIGNANT TUMORS OF BONE.—Relative frequency. In Meyerding and Vall's series of cases of primary malignant bone tumors 50.9 per cent were osteogenic sarcoma; 26.9 per cent were Ewing sarcoma; 9 per cent were fibrosarcoma; 9.7 per cent were multiple myeloma; 7 per cent were giant cell sarcoma; 1.9 per cent had a nonsurgical diagnosis of sarcoma. (J. A. M. A. 117: No. 4, July 26, 1941.)

Osteogenic Sarcoma.—Theoretically this would seem to be a contradiction of my original generalization (page 672) because it is a bone-forming process, but actually the bones on the x-ray plate seem to show more destructive than constructive processes.

In some cases, however, bone tumor forms in abundance and the entire mass ossifies. Osteogenic sarcoma may occur at any age, but is most frequent in the second, third, and fourth decades (43 per cent between the ages of eleven and twenty years; 17 per cent between twenty-one and thirty; 10 per cent between thirty-one and forty years; 5 per cent between sixty-one and seventy years). The femur was the seat of disease in 43 per cent, the tibia in 21 per cent, the humerus in 11 per cent, the fibula in 4 per cent, the pelvis in 4.9 per cent, and the jaw in 2 per cent. Metastasis to the lungs is common.

Fibrosarcoma.—This tumor may arise in bone or in the soft parts. It usually starts within the bone rather than in the periosteum near the end of the shaft and destroys cancellous tissue and eventually the cortex to reach the surface.

Chondrosarcoma.—These may form large tumors naturally situated in cartilaginous regions of the skeleton. The x-ray appearance is of a lumpy tumor with areas of rarefaction.

Angiosarcoma.—This is difficult to differentiate by x-ray from osteogenic sarcoma and fibrosarcoma. Metastases develop early.

Ewing's Sarcoma.—This tumor has given rise to considerable controversy. Ewing says it is an endothelioma and, as Hertzler remarks, he ought to know.

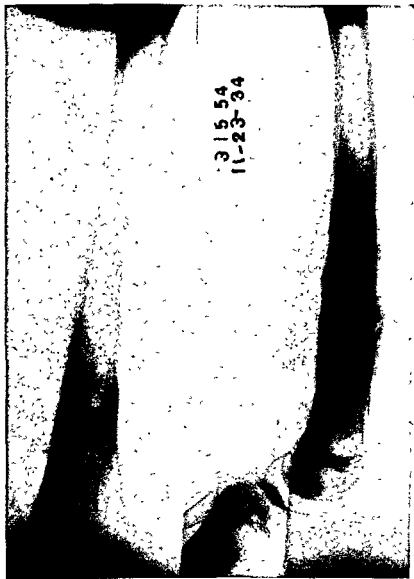


Fig. 78.—Osteogenic sarcoma of femur. Pulmonary metastases.

The second and third decades of life are the most frequent age periods of its occurrence. The distribution is much like that of osteogenic sarcoma. It begins within the medullary canal and produces an infiltrating, soft mass which erodes the cortex within an onionskin-like encasement. The x-ray picture, however, like the microscopic picture is extremely variable.

Multiple Myeloma.—These occur during middle age and in advanced years. It is an osteolytic tumor of bone marrow. The ribs, vertebrae, skull, sternum, femur and humerus are most often involved. They produce rounded, punched-out areas in the bone. They are associated with Bence-Jones proteinuria and possibly parathyroid tumors.

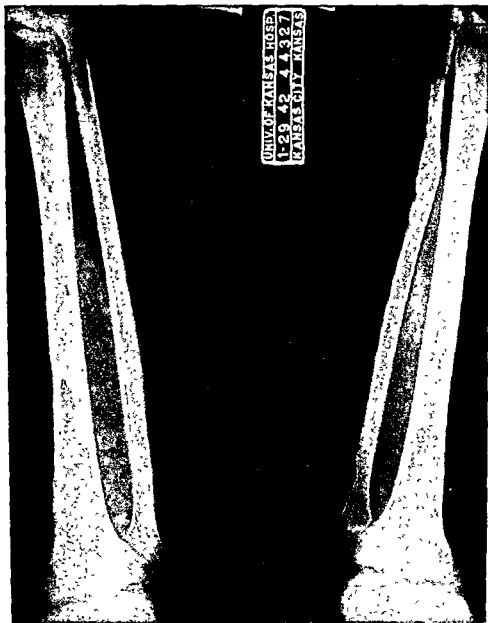


Fig. 73.—Secondary metastases in cancer of breast.

Metastatic carcinoma, from the prostate, breast, thyroid, and kidney are likely to develop in bone. The spine, pelvis, ribs, skull, femur and humerus are the most frequent sites. Roentgenologists classify two types of metastatic

carcinoma—osteoplastic, which infiltrates the bone in which it lodges and produces osteogenesis with the production of spongy bone, and osteoclastic, which destroys bone without ossifying.



Fig. 30.—Secondary metastases in cancer of breast.

ENDOCRINE AND METABOLIC CHANGES IN BONE

Acromegaly is due to hypersecretion of the eosinophile cells of the anterior pituitary, occurring after full adult growth. In earlier life the same condition would cause gigantism. The eosinophile cells are recognized as the source of the growth hormone. Acromegaly is characterized by general overgrowth of the bony structure, particularly the bones of the hands and feet, the maxilla, and the frontal region and vault of the skull. Besides overgrowth in the hands and feet, there is hypertrophic arthritis, and tufting of the terminal digits can be seen on the x-ray plate.

Sella Turcica in Acromegaly.—The growing tumor produces pressure changes in the sella turcica. The x-ray picture of the sella turcica should be measured in all cases. Kieth gives the following average dimensions for the sella:

Anteroposterior diameter	10 to 12 mm.
Transverse diameter	14 to 15 mm.
Depth	8 mm.

These measurements were done on skulls. "In lateral roentgenograms of the living skull, assuming an average distance of four and one-half inches from sella to film, and a target distance of thirty inches, the diameters of the shadow are about 20 per cent greater than the actual bone dimensions." (Hodges, Phenister and Brunschwig.) In a skull dissected by Bassoe and now in the Department of Anatomy in the University of Chicago, the anteroposterior diameter of the sella is 36 mm.

The pressure of the tumor produces what is described as ballooning of the sella. Eventually, in most cases, the tumor fractures the sella, either the clinoid process or the dorsal wings of the sphenoid, and the x-ray plate shows hardly any outlines of the fossa or its walls.

Cretinism.—The fusion of the epiphyses produces dwarfism.

Hypophyseal Dwarfism.—Tumors developing from Rathke's pouch invade the sella and destroy the anterior pituitary, thus inhibiting growth. There is delay in epiphyseal appearance and development and sometimes permanent nonfusion. In the x-ray picture the findings are those of retarded development, somewhat like the skeleton of a normal child of younger age.

Rickets.—The term cartilage-shaft junction is a convenient one in describing rickets. There is a widening of the clear space between the end of the shaft and the nucleus of the epiphyseal body. No ossification centers are seen within the epiphyseal cartilages. The metaphyseal plates of the long bones (particularly the femur and tibia) are irregularly broad and ill defined. The ends of the shafts flare somewhat. The shafts of the long bones are less dense than normal.

Results of treatment or healing rickets show calcification of the epiphyseal centers under way (about three weeks after beginning treatment). New metaphyseal plates have begun to form and there is junction between the epiphyseal cartilage and the newly formed shaft. At the end of about six weeks of treatment calcification is evident, as seen in the x-ray picture. Sometimes after treatment has begun, two metaphyseal plates can still be made out, and from the length of the shaft between the two, the duration of treatment may be judged.

Scurvy.—The signs supposed to provide diagnostic aid are listed by Pelkan as follows:

"1. A fairly irregular, broadened, well-calcified epiphyseal line. (We use the term 'epiphyseal line' to designate the gap between the calcified portions of diaphysis and epiphysis. Pelkan uses it to indicate the end of the diaphysis, a structure which we have called the metaphyseal plate.)

"2. A small spur on the lateral edge of the epiphyseal line or occasionally dislocation of the entire epiphysis.

"3. An area of decreased density, 'the scurvy line,' immediately back of the epiphyseal line, representing lack of calcification of the newly formed spongiosa.

"4. A very thin diaphyseal cortex, often merely a narrow white line.

"5. Glass-like transparency of the shaft; no coarse trabeculation of the sort seen in rickets or some normal bones.

"6. A broad, rather irregular, white edge on the epiphyseal center of ossification of the long bones." (Hodges: *The Roentgen-Ray Diagnosis of Diseases of the Bones and Joints*, New York, 1938, Thomas Nelson & Sons.)

Osteomalacia.—The pathology is nearly the same as that of rickets. In the late healed stage the pelvic deformities are the striking feature.

Gout.—In the early stages little or no change can be seen.

The characteristic bony changes later, as seen on the x-ray plate, are "punched-out areas." These represent depositions of urate salts which have replaced bone. They are not, however, as frequent as would be gathered from the literature. When tophi occur, they show as shadows. A tophus in the olecranon bursa will be a particularly striking lesion. Hypertrophic osteoarthritis is a frequent complication of gout.

Xanthomatosis.—Schüller-Christian disease consists of exophthalmos and diabetes insipidus with patchy erosions of the skull. These patchy areas are due to xanthoma formation. The disease is now regarded as a form of lipoid metabolism disturbance. Niemann-Pick disease is a form in which the tendons are involved. Gaucher's disease may produce similar changes in the bone. All are very rare.

MISCELLANEOUS BONE DISEASES

Aseptic Necrosing Bone Diseases.—All of these consist of localized necrosis of a bone, of unknown cause. The essential feature is death and collapse of all or part of an adult short bone or of the ossifying nucleus of a developing epiphysis. Different forms of the condition have been named on the basis of the location of the lesion.

Osgood-Schlatter's disease is aseptic necrosis of the tibial tuberosity; **Köhler's disease** is necrosis of the patella and tarsal scaphoid in children. **Legg-Perthe's disease** is in the femoral head in young children. **Kienböck's disease** is in the adult carpal semilunar bone. **König** described a type of loose body in the adult knee called "osteochondritis dissecans."

Paget's disease consists of a chronic deforming lesion of the skeleton, characterized by simultaneous absorption of old bone and formation of new bone of a pathologic character in the same field. It is exclusively a disease of adults and, so far as I know, of elderly adults. The deformities which result from this process consist of extreme bowing of the legs of general kyphosis, thickening and enlargement of the cranium, and decrease in stature. Nearly all bones in the body can be affected, but the most usual involvement is sacrum (56 per cent), spine (50 per cent), right femur (31 per cent), left femur (15 per cent), cranium (28 per cent), sternum (23 per cent), tibia (8 per cent). (Schmorl.)

A typical Paget's bone shows on the x-ray plate, deformity (of long bones), thickening, dense wavy trabeculae of cortical and medullary regions and cystlike circumscribed rarefaction. The skull shows an increase in thickness, with spongy and blotchy appearance, and loss or blurring of the outline of the internal and external tables. Dense circumscribed oval or circular areas of increased density are pathognomonic.

Osteitis Fibrosa Cystica.—Cystic bone disease is a localized reaction within the bone, resulting in bone absorption over a localized area and replacement by

fibrous tissue. There may be a solitary bone cyst or multiple cysts (von Recklinghausen's disease). The appearance of a patient with generalized osteitis fibrosa cystica is unmistakable. The tumors appear under the skin, all over the body.



Fig. 81.—Showing the fracture of the left thigh at the time of admission to the hospital, and the characteristic osteitis fibrosa cystica of hyperparathyroidism. Note the absence of any periosteal reaction.

Most of these cases are due to hyperparathyroidism and are helped by the removal of a parathyroid tumor. The subject is more fully discussed on page 218.

Hemophilia.—A hemophilic joint consists of a spontaneous hemorrhage into or around the joint and subsequent organization of the clot. The x-rays suggest tuberculosis of the joints—rarefaction amounting to penciling of the outlines, moderate enlargement and squaring of the epiphyses, erosion of the articular surfaces, and calcification of the organized clot. In late cases there is ankylosis.

Aseptic Necrosis of the Epiphysis.—This group of diseases consists of a softening of the epiphysis, and occurs in the active stage of bodily development during adolescence. The causes are not understood: nutritional deficiency and endocrine disturbance have been invoked. (See paragraph on epiphyseal dysgenesis in the section on hypothyroidism in children.) The softening process may go on to fragmentation and disintegration. The process is much the same no matter what the location. The most frequent locations are:

1. Epiphysis of femoral head—Legg-Calvé-Perthe's disease.
2. Acetabulum—Otto pelvis.
3. Tibial tubercle—Osgood-Schlatter's disease.
4. Tarsal scaphoid—Köhler's disease.
5. Calcaneal epiphysis.
6. Osteochondrosis of the spine—epiphysis of the vertebral bodies.
7. Sacrum—sacroiliac joints.

CONGENITAL ANOMALIES AND ANATOMIC VARIATIONS OF BONE

Spina Bifida.—Failure of the neural arch of the vertebrae to close is spina bifida. In the x-ray picture this is plainly seen as a defect in the laminae, and there is usually an absence of the spinous processes. If the defect is confined to the bony structure, it is known as *spina bifida occulta* which causes no symptoms. If accompanied by a meningocele, it is called *spina bifida vera*, which is likely to cause nervous symptoms. Spina bifida may occur at any part of the spine, as meningocele arnicalis and meningocele sacralis. Circumscribed hypertrichosis in the sacral region (a tail) points to the probability of spina bifida. Spastic paraplegia is caused by spina bifida cerviculis. Paralysis, anesthesia of the legs, bladder and rectum paralysis or incontinence, and perforating ulcer of the foot are the frequent results of spina bifida sacralis.

Supernumerary ribs may arise in the cervical region or the upper lumbar region. Lumbar ribs cause no symptoms and are worthy of note only in that they may be puzzling in interpretation.

Cervical ribs are of decided clinical significance, usually causing symptoms. Thirty-one cases of cervical rib were reported in 80,000 patients at the Mayo Clinic, but they occur more frequently than that according to McWhorter (Surg., Gynec. & Obst., August, 1920)—more than once every hundred dissections by anatomic studies. The symptoms occur in (a) the neck—pulsating tumor of the subclavian artery, thyrotoxic symptoms, dysphagia, atrophy of the larynx and atrophy of the tongue; (b) arm and hand—inequality of radial arteries, Raynaud's syndrome, anesthesia of the arm, atrophy of the arm and shoulder muscles, writer's cramp; and (c) face—Horner's syndrome, unilateral dilatation of a pupil, paralysis of the vasomotor control of one side of the face.

The x-ray diagnosis notes that cervical ribs spring from the seventh cervical vertebra, sometimes from the sixth and seventh. They are bilateral in 75 per cent of cases. Seventy per cent occur in women. Sometimes the rib is flaillike. They usually show no attachment to the sternum. They are easily seen in either chest roentgenograms or studies of the cervical spine. Their size is no criteria of the symptoms produced.

Diseases of the Joints

1. **Acute Arthritis.**—In acute articular rheumatism, the inflammatory process is in the *periarticular tissues entirely*. No changes in these joints can be demonstrated on the x-ray plate.

Acute pyogenic infective arthritis (including gonococcic) can be divided *pathologically and roentgenologically* into three stages:

a. **Invasion**—increase of fluid in the joint and swelling. No x-ray changes except separation of the joint surfaces.

b. **Involvement and erosion of the cartilage.** Destruction of underlying articular cortex. Seen on x-ray plate as fuzzy outlines of the joint surfaces. Differentiation between pyogenic and tuberculous arthritis is made by the regularity with which pyogenic arthritis shows destruction in the weight-bearing areas of the joint surfaces, while in tuberculous arthritis the weight-bearing portion is the last to be involved.

c. **Repair and replacement of destroyed areas by new bone formation and resulting ankylosis.** On the x-ray plate new bone can be seen, especially replacing cartilage which never regenerates.

Gonococcic arthritis is especially likely to destroy large areas of cartilage: it most often affects the knee, starting usually on the undersurface of the patella; next most often the heel, on the plantar surface of the calcaneus.

2. **Chronic Arthritis.**—For practical purposes, the internist, unless he has some original form of therapy in mind, will probably be content to accept the general classification of chronic arthritis as:

a. **Atrophic, or proliferating arthritis**—rheumatoid arthritis or arthritis deformans.

b. **Hypertrophic, or degenerative arthritis**—osteoarthritis.

They are quite as easily distinguished by physical characteristics as by x-ray. The first form, atrophic arthritis, tends to occur in young individuals (in children it is Still's disease), often starting before the age of twenty; the second form usually begins after forty.

The pathologic changes in atrophic arthritis are first in the synovial membrane consisting of fibrous proliferation and round cell infiltration, with eventual destruction of the joint surface entirely. At the edges of the cartilage there is formed a layer of proliferating membrane called pannus and as the disease progresses, the pannus may cover most or all of the cartilage, destroying and replacing it with fibrous tissue. The bone ends themselves may be attacked in this way. The soft tissues also eventually suffer. Ankylosis and deformity are the usual result.

X-ray appearance in the early stages may be negative except to show soft tissue swelling. Later the x-ray plate shows the joint destruction and narrowing and final obliteration of the joint space. Bony ankylosis is finally seen with some osteoporosis of the ends of the bones close to the affected joints. In the very late stages there may be so much bony change that it will be difficult to differentiate between this and the hypertrophic form of arthritis.

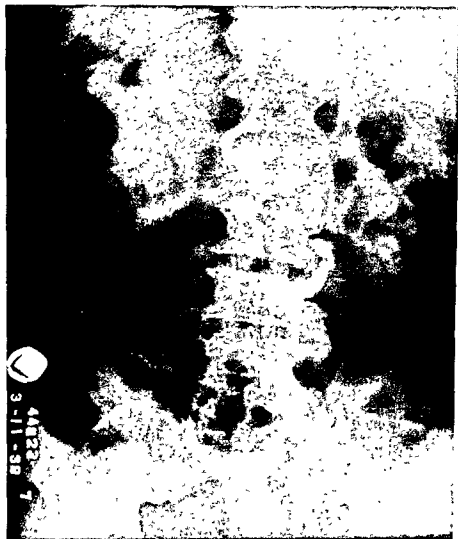


Fig. 82.—Hypertrophic arthritis of spine.

Hypertrophic arthritis is a less well-defined entity. When it attacks the terminal phalanges, the condition is known as *Heberden's nodes*. The involvement of hypertrophic arthritis is usually limited to a few joints, in contradistinction to rheumatoid arthritis which involves nearly all the joints of the body. It is gradually progressive.

The characteristic x-ray appearance of hypertrophic arthritis is overgrowth of bone with ankylosis due to fusion of the two bones around the joint surface. Osteophytes are common, and gradually the joint surface is more or less destroyed with fusion of the two bones.

Of especial clinical interest is arthritis of the spine. This may be largely painless and unnoticed so far as the spine itself is concerned, but may produce referred symptoms of pain, as in the abdomen when they are often misinterpreted.

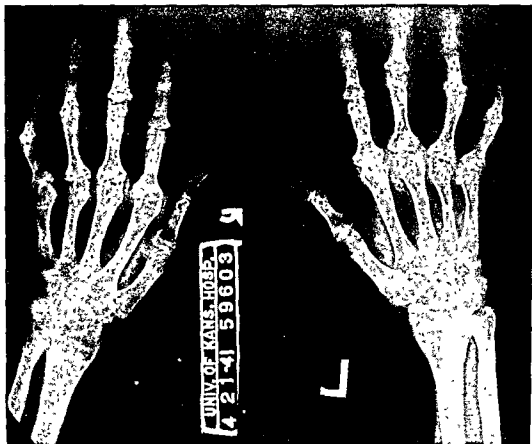


Fig. 83.—Atrophic arthritis.

X-RAY ASPECTS OF LUMBAGO

Lumbago is the term loosely applied to any pain in the back, especially in the lower back. The physician realizes when he uses it that it is nonspecific and that further study is needed to demonstrate the exact pathology. In this study the x-ray is of primary help.

The causes of lumbago may be classified as follows:

1. Muscular.—Myositis of the lumbar muscles from—
 - a. Focal infection of teeth, tonsils, prostate, gall bladder.
 - b. Cold.
 - c. Strain, or injury of the muscles alone.

2. Diseases or injury of the vertebrae.—

- a. Spondylitis from hypertrophic arthritis.
- b. Spondylitis traumatica tarda (Kümmell's disease).

The injury may be extremely slight and may go almost unnoticed at the time. Slowly in the course of several months the spongy body of the vertebra disintegrates and collapses. The posterior portion of the vertebra is protected from collapse by the strong articular processes. The nucleus pulposus is usually dislocated forward. The x-ray picture is negative at the time, and shortly after the injury and begins to show the characteristic changes only after the lapse of some time.

3. Injuries to the pulposus (Schmorl's disease).—The center of the intervertebral disk is the nucleus pulposus, a rounded fluid body which acts as a ball bearing and hydraulic shock absorber. It normally moves with the motions of the spinal column backward and forward. Injury may herniate its fluid contents either (a) upward or downward into the spongy body of the vertebra, or (b) backward into the spinal canal, the situation where it is most likely to cause sciatica and other pressure symptoms, or (c) forward after longstanding herniation it may become calcified. While such herniation may be the result of severe injury, with dislocation or fracture of the vertebrae, the injury that causes dislocation of the nucleus alone may be so slight as not to be remembered later when symptoms of backache or sciatica appear. Rupture of intervertebral discs was first reported by Dandy in 1919 in two patients on whom he operated: since then, he states, that this has become the most frequent lesion encountered by neurosurgeons.

The common method used to locate the lesion is by the injection of iodized oil into the spinal canal. Dandy (J. A. M. A. 117: No. 10, Sept. 6, 1941) makes an eloquent and convincing plea against this procedure and states that proper interpretation of the history, the physical examination, and a plain x-ray without contrast media of any kind usually is sufficient for a diagnosis. Reichert (West. J. Surg. 47: 297, June, 1939) reported the successful use of air injections as a contrast medium.

Air injection, or oxygen, is harmless and will demonstrate larger intraspinal herniations. The trend away from lipiodal injections into the spinal canal is sensible. Most orthopedic surgeons and neurosurgeons now operate on the basis of clinical symptoms. When any heavy opaque media is used within the spinal canal, there should be an attempt to rescue most of it from below the site of the obstruction. Some less objectionable opaque medium will probably replace lipiodal.

Most of the cases of ruptured vertebral disks occur at the fourth and fifth lumbar interspaces (96 per cent). "The diagnosis is made on low midline lumbar backache plus pain down the back of one or both legs, the pain is intensified by coughing and sneezing, and the pain must be recurring and not continuous. There may or may not be diminution of the achilles reflex or sensory or motor loss in the distribution of the fourth or fifth lumbar or first sacral nerve." (Dandy op. cit.) (See also Barr, Hampton and Mixter: Pain Low in the Back and Sciatica, J. A. M. A. 109: 1270, Oct. 16, 1937; and Spur-

ling and Grantham: Neurologic Picture of Herniation of the Nucleus Pulposus in the Lower Part of the Lumbar Region, Arch. Surg. 40: 375, March, 1940.)

4. Anomalies of the Vertebral Articulations.—Taylor (Anomalies of the Lumbosacral Articulations, J. A. M. A. 113: No. 6, Aug. 5, 1939) has called attention to the variations that occur in the articulations of the lumbar vertebrae and of the lumbosacral articulations. Many persons have articulations that are structurally very faulty. For instance, the articular facets, instead of facing laterally and obliquely which gives a stable back, may face anteroposteriorly, or in a straight line facing caudad, cephalad. These are potentially weak, and persons with such joints are unsuited to hard manual labor, such as lifting and straining. They are more liable to injury and consequent backache and this can be predicted by an x-ray study. (Or rather in a person with a chronic backache, when the x-ray picture shows such structural variations, the backache can reasonably be blamed on such potential weakness.) Goldthwaite (Backache, New England J. Med. 209: 722, Oct. 12, 1933) stated that muscular strains and fascial tears do occur, but by far the commonest trouble in backache is with the mechanism of the joints.

5. Spondylolisthesis is a condition in which one or more of the lumbar vertebrae become displaced on each other or the sacrum. The cause is seldom a single intense trauma, but more often less severe strain over a long period of time, as from heavy lifting. It affects most often the fifth lumbar vertebra and the spine. X-ray pictures taken laterally will show the position of the vertebra on the sacrum.

Spondylolistheses are usually found in spines that show developmental defects in the vertebral anatomic development at the lumbosacral spine. They do not of themselves produce pain or discomfort. An injury, repeated stress or strain, postural habits of occupation or exercise may produce enough pain to demand the x-ray examination and discovery of the condition.

6. The sacrolumbar joints.

7. The sacroiliac joints.

8. Lumbago due to kidney stone or gallstones (reflex) may be revealed by the x-ray plate.

X-RAY DIAGNOSIS OF PAIN AROUND THE JOINTS

Besides frank infectious arthritis, tuberculous arthritis, reflex pain from osteomyelitis, and obvious fracture or dislocation, the internist may have to interpret pain around joints of a more or less chronic character in which the history does not reveal the relation of onset to definite trauma. In such circumstances he must think of the following conditions which can be revealed by the x-ray.

Wrist and Hand.—Kleinboch's disease—traumatic osteitis of the carpal bones, affecting usually the semilunar (most frequent) and scaphoid bones. It occurs most often in males between twenty and thirty years of age. The cause is usually repeated trauma, such as striking the butt of the hand in some manufacturing process. Interference with the normal blood supply of the

bones is thought to be the cause. On the x-ray plate the bone is seen to have lost its normal shape and is denser than normal: there may be cystic degeneration.

Toe.—Freiberg's infraction, *Osteochondritis deformans metatarsojuvenilis* is an osteochondritis of the metatarsophalangeal joint of the second or third toe, occurring most frequently in adolescence, but remaining throughout life. It is probably caused by repeated pressure trauma applied to the head of the metatarsal bones. It is seen in toe dancers. Usually, however, no etiologic factor can be found. On the x-ray plate the head of the involved metatarsal bone shows destruction with quiet subchondral necrosis of the bone without evidence of pyogenic infection. There is pain and discomfort, but not enough to be disabling. Surgical removal of the involved area usually makes the discomfort worse.

March Fracture.—This is localized proliferative overgrowth of periosteal new bone of the distal portion of one or more tarsal bones. History of direct trauma is usually not obtained. It is seen in nurses and others who have to be on their feet a long time. The periosteal thickening is always related to the insertion of the interossei muscles. In differential diagnosis it has been mistaken for malignancy, and bones removed for that cause have shown microscopic evidence of fracture. Similar conditions are occasionally seen in tibiae in soldiers of a new draft after strenuous unaccustomed marches.

Knee.—*Osteochondrosis dessicans* occurs in adolescence or young adult life, and is characterized by slow subchondral necrosis, with separation of a small triangular fragment of the articular cortex of the bone, usually on the inner condyle of the femur. It seems to be caused by interference with the blood supply of the part by repeated trauma. It is definitely not pyogenic. It may be bilateral. It occurs in the humerus. On the x-ray plate the articular cortex of the involved joint shows a small piece of bone, separated from the main bony structure by a zone of rarefaction. The articular cartilage may hold it in place, or it may necrose through and become a foreign body in the joint: surgical removal is then indicated, but ordinarily the condition produces only slight disability.

Pellegrini-Stieda's Disease.—Traumatic calcification of the collateral tibial ligament of the knee (a calcium deposit in the collateral tibial ligament resulting from minor trauma after several months). The x-ray picture shows the calcification in the soft tissues along the inner side of the joint. X-ray studies are negative until some weeks after the inciting injury. Prognosis is guarded.

Hip.—*Femoral osteochondrosis or slipping femoral epiphysis* occurs in adolescence; it consists of slipping epiphysis at the head of the femur. It occurs most frequently in males at the ages of twelve and fifteen. The cause is not known, but it is ascribed to poor circulation, possibly following trauma. The symptoms are pain and disability; later there is some shortening, limitation of motion, and deformity. The x-ray picture shows the epiphysis of the head of the femur as a dense sclerotic body. The head remains in the acetabulum, but the diaphysis and neck of the femur are displaced upward.

X-ray Diagnosis of Diseases of Muscles, Bursae, and Veins

Myositis ossificans traumatica is the deposit of calcium in striated muscles. It follows trauma with interstitial hemorrhage into the muscle. The clots organize by calcification. The condition may be mistaken for rheumatism. The x-ray picture makes the diagnosis very certain. The calcium deposits arrange themselves along the muscle fibers, but do not enter the tendons.

Calcium deposit in bursae as a result of injury or inflammation or chronic (occupational) irritation is very common. The most frequent sites are the prepatellar and the subacromial, or subdeltoid, bursae. On the x-ray plate the calcareous deposit gives the appearance of a density in the region of the bursa.

II. X-RAY EXAMINATION OF THE HEART AND GREAT VESSELS

1. Shadows of the Cardiac-Aorta Area

An ordinary plate of the chest shows quite distinctly the outline of the continuous shadow of the aorta, heart, pulmonary artery, and diaphragm. In health, these present a profile with a succession of curves. On the left side, from above downward, there is the aortic notch representing the junction of the ascending and transverse aorta. Just below it, not always prominent, is a curve made by the pulmonary artery; below that, the curve of the left auricle. Last, the large curve of the left ventricle, meeting the diaphragmatic curve at a sharp angle. On the right side the upper part of the shadow representing the aorta is smooth. Then coming downward there is a prominence representing the right auricle, which also makes a sharp angle at the junction of the right diaphragm. (The right ventricle occupies the largest part of the presenting surface of the heart when viewed anteriorly. In other words, if you lift the anterior chest wall and reflect the pericardium, all you see is right ventricle, with a fringe of left ventricle peeping out to the left and a fringe of right auricle peeping out to the right. When the right ventricle enlarges, however, it either pushes the right auricle to the left or behind so that the shadow in right ventricular preponderance is well over the right sternal border. In the *cor pulmonale* of emphysema not only is this true, but the enlarged right ventricle also displaces the left ventricle dorsally).

2. Heart Shadows or Silhouettes

The great general types of heart disease give characteristic shadows of enlargement.

Mitral disease presents a general enlargement of the heart shadow, definitely jutting out to the right of the right border of the sternum. There is also enlargement to the left. The heart shadow in general is globular, hanging from the shadow of the aorta, something like the outline of a fat pear. In extreme degrees of mitral stenosis, the shadow of the left auricle is prominent.

Aortic disease gives a predominant left-sided enlargement, representing the hypertrophied left ventricle in this disease.

Hypertension shows less prominent, but still predominant, left-sided enlargement.

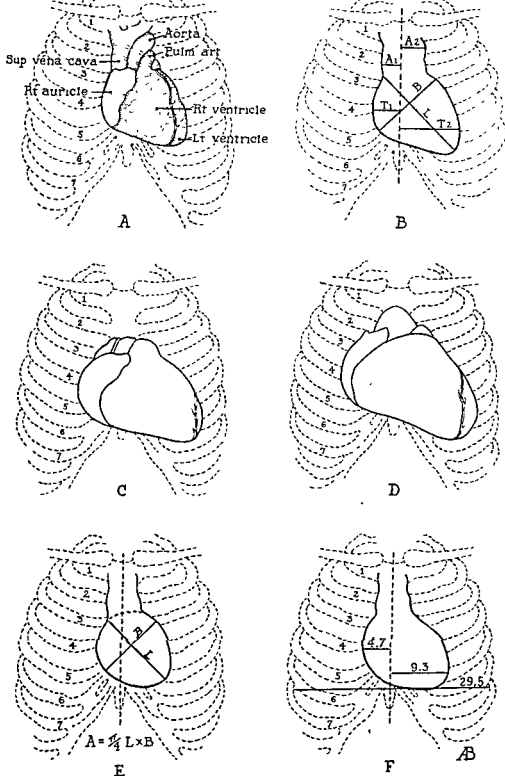


Fig. 81—Diagram of anteroposterior x-ray shadow of the heart and great vessels. A, the structures which throw shadows on the anteroposterior x-ray plate; B, classical measurements of the cardiac-great vessel shadow; C, mitral stenosis; D, aortic regurgitation; E, normogram. (Area of frontal cardiac silhouette in relation to standards based on weight and height gives an excellent criterion of heart size. A =area of ellipse, L =long diameter, B =broad diameter); F, cardiothoracic ratio: $\frac{\text{Transverse diameter of heart}}{\text{Internal transverse diameter of chest}} = 47\%$ which is normal

Pericardial Effusion.—Small pericardial effusions gravitate to the bottom of the sac, and there is obliteration of the acute cardiophrenic angles. The cardiac outline is of "a triangle suspended by the neck." As the effusion increases in size, the divisions in the profile of the heart chambers become obliterated and the sac bulges outward beyond its diaphragmatic attachments. The outline suggests general cardiac dilatation and the differential diagnosis "may strain all the resourcefulness of the radiologist," so I am informed by radiologists. But the clinician should be able to tell by the general condition of the patient whether "dilatation," certainly of that extent, is present. And the x-ray picture may be the first hint in the course of, or convalescence from, rheumatic fever that pericardial effusion is present.

Adhesive pericarditis (pleuropericardial or phrenopericardial adhesions) under the fluoroscope, tugging of the heart on with systolic dislocation of the adjacent diaphragm or pleural borders may be seen.

Calcified pericardium is easily made out.

Congenital heart disease.—With patent ductus arteriosus, the aorta may be small, with an enlarged pulmonary artery below it.

Patent foramen ovale (interauricular septal defect) produces, when large, enlargement of the auricles.

Congenital pulmonary stenosis produces right ventricular enlargement. It is seldom seen alone, unassociated with other defects.

The tetralogy of Fallot is pulmonary stenosis, patent interventricular septum, hypertrophy of the right ventricle, and dextro position of the aorta. X-ray diagnosis is not usually specific. Enlargement, especially of the right ventricle, somewhat to the left, prominent pulmonary artery conus, and small aorta should be looked for.

Congenital Idiopathic Dilatation of the Pulmonary Artery and Its Branches (Oppenheimer: Tr. A. Am. Phys. 48: 290, 1933).—The diagnosis is entirely by x-ray examination. Dilatation of the pulmonary artery with advanced enlargement of the right ventricle.

Right-sided Aorta.—The aorta is developed from the fourth branchial artery on the right side instead of on the left. The aortic arch passes behind the esophagus and trachea, causing esophagus and trachea to be displaced to the left. A barium meal brings this out. The condition is of no pathologic significance, but may be mistaken for such unless the examiner is familiar with it.

Situs inversus is plainly obvious on the x-ray plate.

Ayerza's disease is cyanosis with gradually increasing change in the pulmonary vessels. The x-ray plate shows a prominence of the pulmonary artery with masses of dilated vessels about both lung roots. These show active pulsation. There is right-sided cardiac hypertrophy.

3. The Aorta

Dilatation of the aorta in aortic syphilis is diffuse and classically limited to the ascending aorta.

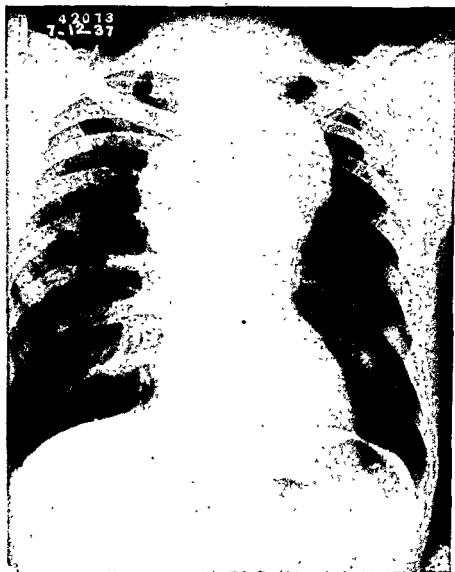


Fig. 85.—Aneurysm of aorta.

Arteriosclerosis of the aorta is largely limited to the transverse and descending aorta. Calcified plaques may be made out, but are rare. The aortic knot is prominent and sharp in arteriosclerotic aortitis. Dilatation is not a feature, but there is often a lengthening of the aorta in the longitudinal dimensions with tortuosity. Examination of the patient in the lateral position may be helpful in making a diagnosis.



Fig. 86.—Aneurysm of aorta and heart.

Coarctation of the aorta is a constriction or narrowing of the aorta opposite, or a little below, the ligamentum arteriosum. The collateral circulation is set up by the internal mammaries, the descending branches of the transverse cervical and inferior epigastrics, etc. X-ray pictures show the aortic knot usually absent, the ascending aorta enlarged or prominent, and the heart en-

larged. Erosion of the ribs may be seen. In the oblique position it is sometimes possible to demonstrate the structure or the absence of the usual shadow cast by the ascending aorta.

Aneurysm.—For thoracic aneurysm the x-ray plate is not only the court of last resort; it may be called the discoverer of aneurysm. With physical diagnosis alone, we miss entirely, or could not positively identify, at least 50 per cent of aneurysms. In clinics where a routine x-ray study of the chest is made on all suspicious cases, no case of aneurysm of the ascending and transverse aorta should be missed. Osler's old distinction between the aneurysm of symptoms and the aneurysm of signs disappears with the employment of the x-ray.

Aneurysms of the ascending aorta appear to the right, while aneurysms of the transverse arch appear to the left. Aneurysms of the descending aorta may be hidden behind the shadow of the heart. An oblique view should bring them out.

Aneurysm of the subclavian artery or carotid not in proximity to lung structure, is usually invisible on the x-ray plate. It is the air in the alveoli furnishing a background which brings out the thoracic aneurysms.

The differential diagnosis between solid mediastinal tumor and aneurysm should be made under the fluoroscope by noting the pulsation of the aneurysm. But this is more theoretical than practical. It is extremely difficult to differentiate between expansile and transmitted pulsations. More important than pulsation is the position of the sac. The outline of an aneurysm is sharp. A mediastinal tumor is not always clearly defined. The shadow of the aorta may be seen through the mediastinal tumor shadow.

In aneurysm with asthmatic or atelestatic symptoms, note the condition of the trachea. I remember a patient who had been treated for allergic asthma for six months, when finally a hemorrhage provided his exitus. At autopsy the trachea was found compressed to a flat, thin lumen.

4. Exact Heart Measurements

For making exact measurements of the heart and great vessels by the x-ray either an orthodiagram, a teleroentgenogram, or a kymograph must be made. (*See diagram, Fig. 84.*)

Procedure.—With the shadow on the orthodiagraph or plate, a vertical line is dropped from the midsternal notch. (This need not be plotted accurately because the sum of the maximum right and maximum left is going to be the same no matter where it is drawn.) Lines are drawn from this longitudinally at the point of the extreme extent of the borders of the right (M. R.) and left (M. L.) heart; the sum of these is the maximum transverse diameter (T. D.) of the heart. A transverse line is drawn across from the borders of the widest part of the aorta. An oblique line is drawn from the border of the shadow of the apex, to the shadow representing the junction of the great vessels and right auricle, called longitudinal diameter (L. D.). Lines perpendicular to this are drawn on the left to the junction of the left auricular and left ventricular shadow (B. D.).

The transverse diameter and the longitudinal diameter depend normally on the height, weight, and constitution of the individual. Clayton and Merrill give these measurements:

WEIGHT IN POUNDS	MEN	TRANSVERSE DIAMETER IN CM. M. R. - M. L.	LONGITUDINAL DIAMETER IN CM.
109-117	Minimum	10.7	11.8
	Average	10.9	12.6
	Maximum	11.3	13.5
118-126	Minimum	11.0	12.0
	Average	11.8	13.2
	Maximum	12.5	14.0
127-135	Minimum	11.0	12.0
	Average	11.9	13.4
	Maximum	13.1	14.5
136-144	Minimum	11.5	12.5
	Average	12.3	13.5
	Maximum	13.0	15.0
145-162	Minimum	12.0	14.0
	Average	12.4	14.6
	Maximum	13.8	15.3
163-181	Minimum	11.0	14.0
	Average	12.9	14.7
	Maximum	13.4	15.8
WOMEN			
91-99	Minimum	9.9	12.0
	Average	10.2	12.1
	Maximum	10.5	12.3
100-108	Minimum	10.0	11.5
	Average	10.7	11.9
	Maximum	11.1	12.4
109-117	Minimum	10.2	10.3
	Average	11.0	12.2
	Maximum	12.2	13.8
118-126	Minimum	9.6	11.2
	Average	11.2	12.4
	Maximum	12.6	13.3
127-135	Minimum	10.0	12.2
	Average	11.1	12.7
	Maximum	11.8	13.2
136-144	Minimum	10.9	12.3
	Average	11.6	12.9
	Maximum	12.8	14.2
145-159	Minimum	10.6	11.8
	Average	11.7	12.6
	Maximum	12.6	13.2

III. DISEASES OF THE RESPIRATORY SYSTEM

X-Ray Examination of Nasal Accessory Sinuses

The internist will seldom be called upon to interpret x-ray plates of the accessory sinuses of the nose, but he should have at least a bowing acquaintance with them.

The sinuses, since their air content furnishes a contrast to the bones of the skull, can be clearly seen on the x-ray plate—the maxillary antra below, the ethmoids between the nasal cavity and the orbits, and the frontal sinuses above. The sphenoidal sinuses appear best on a lateral plate. The antra appear a few months after birth, the ethmoids next, and the sphenoidal and frontal sinuses at from four to eight years of age.

Infection of the sinuses can be detected in various stages. In acute catarrhal infections there is congestion and edema which results in blurring of the shadows. Chronic infection produces rarefaction of the septa of the ethmoids. In purulent infections the secretions are usually dammed back into the sinus, the air is displaced, and the sinus appears opaque. Granulations, polypi, and hyperplastic inflammation of the mucous membrane of the sinus, especially the maxillary and frontal antra, can sometimes be detected on the x-ray: the sinus may become so filled with granulation tissue that no air space remains. Atrophic sinusitis may produce, by long-standing infection, condensing osteitis with irregular bony deposits on the wall, limitation of the size, and, in the case of the ethmoids especially, obliteration of all landmarks.

Tumors of the sinuses are mucocele, meningocele (frontal), ivory osteoma, sarcoma and carcinoma. They have, in most instances, the same density as products of infection.

The Trachea.—The outline of the trachea—not a shadow, but just the opposite, a clear space—can be easily seen in the x-ray plate. Displacement of the trachea, as by the drag of a chronic pulmonary or pleural disease, is a confirmatory sign; in the case of chronic, long-standing inflammatory conditions—emphysema, pleural thickening, fibrous pulmonary tuberculosis, or lung abscess—the trachea is pulled to the side of the lesion. The thyroid may displace the trachea, as may retropharyngeal abscess. Compression of the trachea may occur from aneurysm or goiter. Thymus pressure is not so easily demonstrable.

The demonstration of foreign bodies in the trachea or bronchi is a most valuable addition to diagnostic procedure. In obscure cases of asthma, abscess, or respiratory distress, the finding of a foreign body clears up the whole picture. In the trachea, disc-shaped foreign bodies, such as coins, tend to lodge edgewise because the posterior part of the trachea being noncartilaginous accommodates them more easily.

The Bronchi.—Obstruction, stenosis of a bronchus, either from foreign body or from new growth (bronchogenic cancer) may or may not lead to the atelectasis of an entire lobe of a lung. The air in the lung is rapidly absorbed, the alveoli collapse, and the lung area appears as a density on the x-ray plate, like a consolidation. One of the startling, and to the uninitiated, puzzling things about this condition is that the stenosis may relax, and one day there is a density, the next day a perfectly clear lung field. A ball-valve type of obstruction, which lets air into the lung but none out, may result in emphysema and increased radiolucency on one side. Under the fluoroscope the diaphragm

is seen depressed and more or less immobile, and the mediastinum swings back and forth, a phenomenon observed by Manges.

Bronchiectasis.—Whooping cough and chronic nasal sinus infection should be considered as etiologic factors in bronchiectasis. Multiple saclike enlargements of the terminal bronchi occur. The sputum is profuse, and a condition of chronic invalidism with loss of weight, frequent attacks of reinfection, and sensitiveness to changes of temperature and draughts are the complaints.

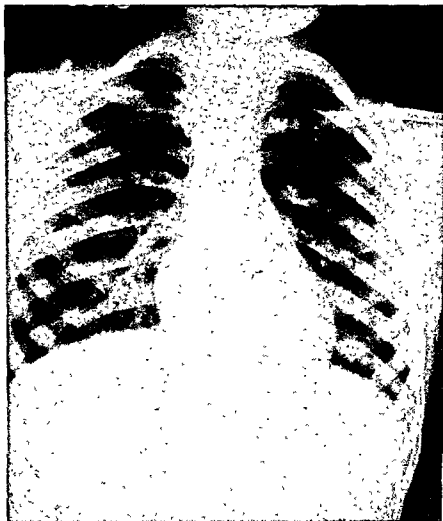


Fig. 87.—Normal chest at five years of age.

Physical examination gives little definite aid in most cases. In the x-ray picture an increase in density and complexity of the hilus shadows can often be seen, but it is quite as likely that the plain x-ray gives little aid. The introduction of lipiodal outlines the bronchial tree and reveals the bronchial terminal dilatation. In normal chests the lipiodal quickly enters the alveoli, where the only way it can be removed is by phagocytosis. The lipiodal in the bronchial tree is coughed up completely within twenty-four hours, but the lipiodal

in the alveoli remains for months sometimes. In bronchiectasis the lipiodal does not enter the alveoli and that in the bronchi is all coughed up. These differences constitute an important point in diagnosis.

The Lungs.—Passive pulmonary congestion in heart failure is detectable on the x-ray plate by engorgement of the vessels and an increase in the lung

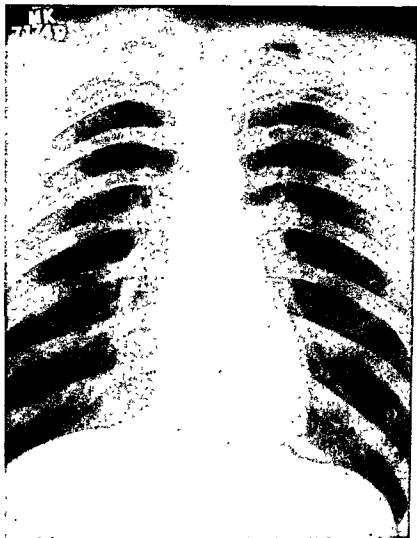


Fig. 88.—Normal chest at twenty years of age.

markings in the inner lung fields. It has never seemed to me a very reliable diagnostic sign, however; physical methods of diagnosis are far superior in making this diagnosis.

Pulmonary infarct can be seen in many instances in the x-ray plate as a triangular shadow with its base against the pleura and the apex pointing toward the hilus.

Lobar Pneumonia, Bronchopneumonia, etc.—These processes produce shadows on the x-ray plate, but, personally, I am opposed to the use, or even the suggestion of the use, of the x-ray in acute, severe respiratory infection. The primary indication in management of such cases is rest, and the effort required to make an x-ray plate is a violation—an unnecessary violation—of this principle. Unnecessary, because if a physician cannot make a diagnosis of pneumonia, he had best turn in his stethoscope and quit. As I have said

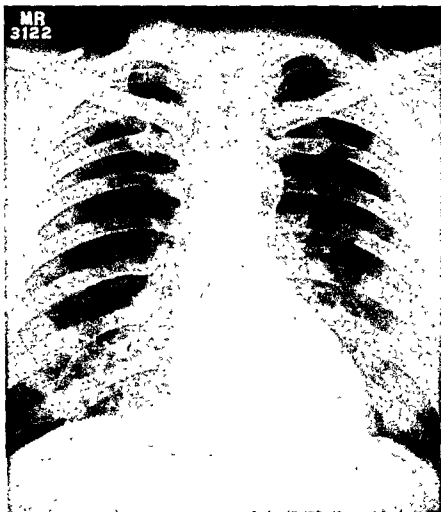


Fig. 89.—Normal chest in adult, fifty years old.

in another place (see *Methods of Treatment*) the fact that the patient has two lobes involved instead of one, does not make any difference; you are not going to give twice as much medicine or serum. However, if x-ray plates are to be made, it is perfectly simple to interpret them when either lobar or bronchopneumonia is present, provided one has an elementary knowledge of lung anatomy and topography and of the pathology of the conditions.

Pulmonary Tuberculosis.—The x-ray now holds a primary and indisputable place in the diagnosis of early pulmonary tuberculosis. In a routine ex-

amination of a group to detect early tuberculosis, as in a general population, in an industrial group, or for army or insurance application, the physical examination will fail to detect 25 per cent of early cases and 5 per cent of late ones. There are some instances of even advanced lung destruction that either lies too deep or for some other reason simply cannot be detected by percussion or auscultation. The error in diagnosis from the x-ray plate in routine examinations, if good technique and interpretation are assumed, should be not greater than 2 per cent in early and none in late cases. The fluoroscope is little better, if at all, than percussion and auscultation.

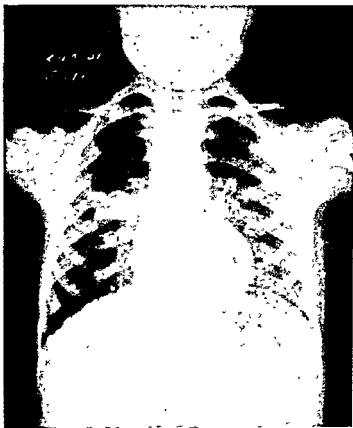


Fig. 30.—Tuberculosis of lung. Epituberculous reaction showing clearing later on.

The pathology of pulmonary tuberculosis is now apparently thoroughly settled. It is difficult to conceive of the introduction of a new concept sufficiently revolutionary to upset our present views. According to this concept pulmonary tuberculosis begins in the great majority of cases in childhood or even infancy. The first infection is usually from an unsuspected member of the family. The incidence of primary infection, according to Myers, depends upon where a person lives. In a New York slum area the incidence is higher than in a sparsely settled area. The infection is almost certainly by way of the respiratory tract. (*Die primäre Lungenherd bei der Tuberculose der Kinder, Berlin, 1912.*) The tubercle bacilli enter the respiratory tract and

establish themselves where we would expect them to establish themselves, in the lower right lobe, following gravity and the widest and straightest bronchial pathway. To objections that they cannot pass the natural resistances of the bronchi, we may reply that carbon particles do so, why not tubercle bacilli? In the lung they set up a primary reaction—the tubercle of Ghon.

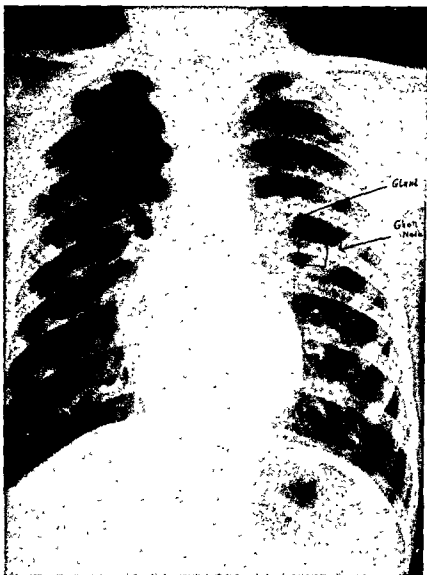


Fig. 31.—Varieties of tuberculosis of lungs as seen in x-ray picture. Primary Ghon nodule and enlarged gland (Ranke complex).

This is usually in the right lower lobe, but may be anywhere in the lungs. The tubercle of Ghon is not usually observable until it becomes calcified or fibrotic. This infection may become healed and the clinical course of the case thereby stopped. Ghon's tubercle can be identified in many human chests. If the disease progresses, the next course of extension is to the hilus and tracheobronchial glands. This is the typical form of childhood respiratory tuberculosis with no involvement of the parenchyma.

Adult tuberculosis consists of involvement of the parenchyma and is an entirely different clinical disease from childhood tuberculosis. Tuberculosis of the lung parenchyma occurs from the release of tubercle bacilli from the tracheobronchial lymph nodes into the bronchi. The infection involves, in most instances, the apices of the upper lobes. Why this should be is a matter of uncertainty. The explanation which has most nearly satisfied me is that if the chest of a person who has had a lipiodal instillation is observed under the

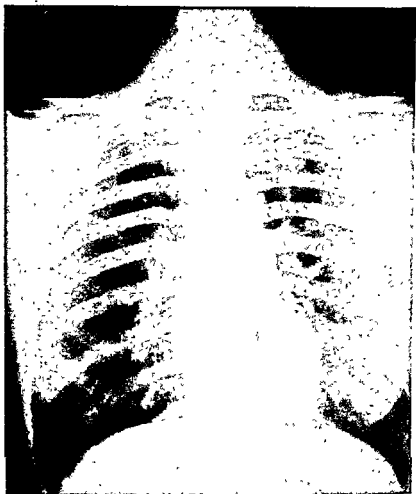


Fig. 92.—Tuberculosis of lungs Miliary lesion of left infraclavicular area in adult.

fluoroscope, and he is asked to cough, the lipiodal is forced into the apices with a sudden explosive rapidity and for a moment outlines the bronchioles of that region. Why shouldn't the tubercle bacilli, released into the bronchi, cause cough and do the same thing?

The x-ray film of early tuberculosis of the parenchyma of the lung shows the tubercle. This appears on the negative as a solitary, discrete, soft, white spot with furry edges, and has been compared to a snowflake.

The early tubercle or tubercles are usually seen below the clavicle—a fact to emphasize, because physical diagnosticians have spent their youth hammering away and listening above the clavicle. The first involvement is below the clavicle; the apical branches of the bronchi are at right angles, whereas the subapical branches are at about twenty degrees angulation, which facilitates the entry of infected material to the subapical rather than the apical regions.

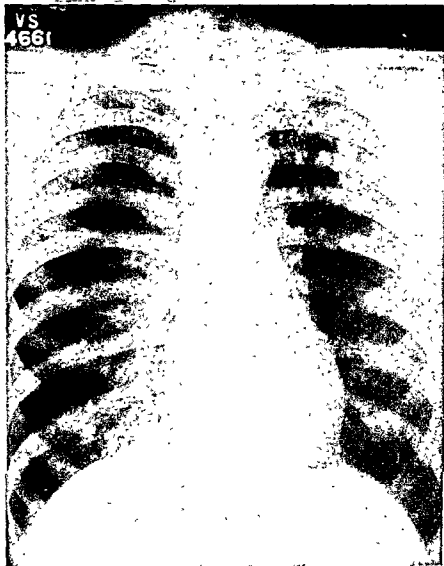


Fig. 92.—Varieties of tuberculosis of lungs as seen in the x-ray picture. Unilateral apical involvement of left infraclavicular area.

"Assman described this focus as a round, sharply defined opacity in the right subclavicular region, with a density which was slight. He found on post mortem that this opacity was a localized caseous pneumonia, deep in the middle of the upper lobe and, as a rule, in the neighborhood of the lateral and dorsal ramifications of the subapical branch of the posterior upper lobe bronchus. This would suggest that the adult infection is more probably a

reinfection, rather than secondary to an old infection. Associated with this early focus, cavities may be present.

"The appearance of the primary focus varies in density and contour. It may be multiple and resemble a cluster of grapes, or in the form of a gradually fading density, limited by the inter-lobar fissure, and due to a caseous pneumonia.

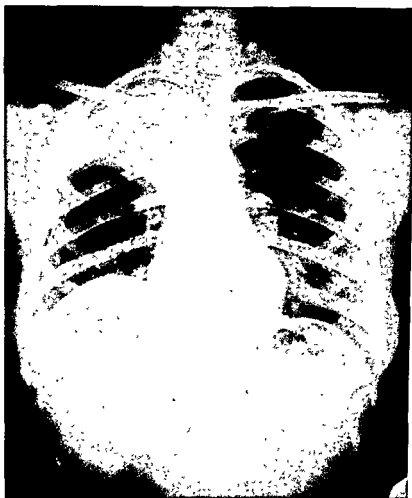


Fig. 94.—Tuberculosis of lungs. Pneumonia or exudative lesion

"Fortunately, provided the resistance is good, the focus remains at the apex and ultimately heals. Like the childhood type, however, extensive caseous pneumonia or miliary tuberculosis may quickly develop at any time during the disease." (Banner: William Wood & Co., 1937.)

After such primary infection has occurred, the pathologic changes may take several courses:

Healing may occur with calcification or fibrosis of the early lesion.

Pleural effusion may occur. (See below.)

The primary focus may become active and spread as a caseous pneumonia. The occurrence of cavitation and fibrosis and exudation may go on simultaneously.

A cavity shows on the x-ray plate as an area of diminished density in which there is an absence of lung markings. The wall may be thin or heavy and fibrotic. Small fluid levels in cavities are seen occasionally, but not very often, and cannot be set up as a diagnostic criterion for cavity.



FIG. 95.—Varieties of tuberculosis of lungs as seen in x-ray picture. Extensive chronic fibroid tuberculosis.

Spontaneous pneumothorax may occur.

Pneumothorax, whether spontaneous or induced, is readily seen and early recognized on the x-ray plate. The air spaces show entire absence of lung markings, and the edges of the collapsed lung can be made out against the

hilus, or often attached by adhesions to the chest wall. Small masses of fibrin—a "mouse"—are often seen resting on the diaphragm in induced pneumothorax and have no significance.

Miliary tuberculosis is revealed on the x-ray plate as a characteristic, fine, hazy mottling scattered evenly throughout both lung fields. The shadows of each miliary deposit are distinct and usually discrete and not coalescent. (Some phases of miliary infiltration are not discernible upon roentgen films.) The x-ray finding of miliary tubercles has cleared up many diagnostic puzzles. Differential diagnosis between it and pneumoconiosis and metastatic malignant deposits presents the only difficulties.

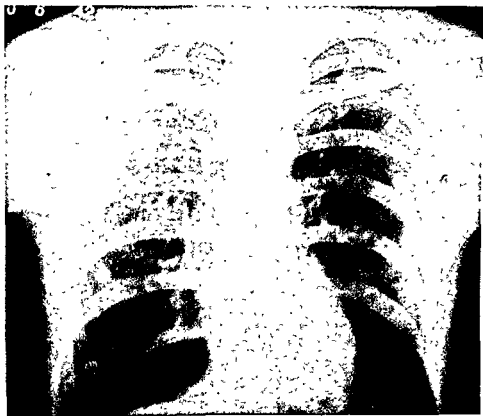


Fig. 36.—Varieties of tuberculosis of lungs as seen in the x-ray picture. Advanced lesion with cavity formation.

FUNGUS INFECTIONS OF THE LUNGS

Actinomycosis does not present any characteristic x-ray picture. Often it resembles tuberculosis. When it invades the ribs and chest wall, such findings are more specific.

Blastomycosis also resembles tuberculosis and presents nothing specific.

Aspergillosis shows countless numbers of small, soft, rounded infiltrations uniformly scattered throughout both lung fields. It does not resemble ordi-

nary tuberculosis because the lesions are uniform in distribution and throughout all parts of both lungs. It can be differentiated from miliary tuberculosis because the lesions are much larger and the patient is not so profoundly ill as in miliary tuberculosis. Second-stage silicosis resembles it somewhat. It is an occupational disease in that farmers and pigeon-feeders who fill their mouths with grain are the victims.

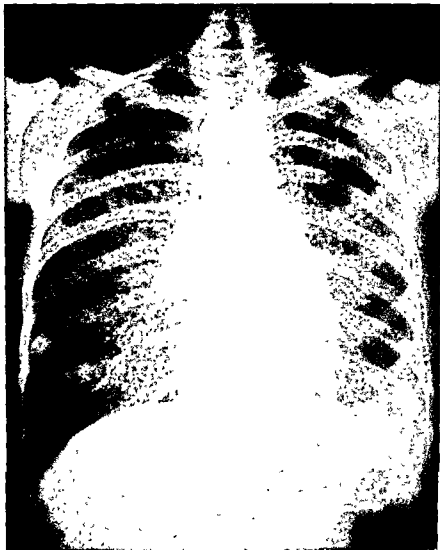


Fig. 97.—Varieties of tuberculosis of lungs. Miliary tuberculosis.

Syphilis of the lung, aside from congenital syphilis and white pneumonia of the newborn infant, though often described, is, in my opinion, nonexistent. As described, it presents as a triangular area of dullness, the base against the pleura, the apex toward the hilus. I once started out to find cases of syphilis of the lung. I asked my colleagues in hospital and dispensary service to find them for me. I chased over the area of two cities for months and never found

one proved case. Most of the suspects were pleural effusion or lung abscess or Vincent's infection of the lung. Finally a patient with a diagnosis of syphilis of the lung, and a shadow in the lower left lung, came to autopsy. The specimens were sent to a number of pathologists: about a third said they might be syphilis, a third said they might be fibroid phthisis, and a third refused to commit themselves. If such a difference of opinion occurs when tissue specimens are available, what can the clinician hope to accomplish? The therapeutic test is not convincing because Vincent's infection responds favorably to arsphenamine.



Fig. 98.—Tuberculosis of lungs. Calcified healed disseminated tuberculosis.

Lung abscess occurs most often in one of the lower lobes. It throws a shadow on the x-ray plate characterized by a diffuse density, ill defined at the edges, more dense in the center, and subject to changes in density as the abscess is emptied. A lung abscess may be mistaken for tuberculosis or pneumonia or empyema. Multiple abscesses may occur. Etiologically, nowadays, most abscesses are due to infection from the throat or mouth with Vincent's organisms. Postpneumonic abscesses also occur.

Pneumoconiosis.—The particular substance in dust which is deposited in lung tissue and causes trouble is silica. Silicosis from hazardous occupa-

tions develops only after about two years' exposure to dust, except in very rare instances of acute silicosis. The disease is observed roentgenologically in three stages: first, an increase in hilus shadows and lung markings of the lower lobes; second, nodulation and beading along the bronchi; third, large, distinct blotchy areas throughout the lung, occasionally cavity formation and small areas of pleural effusion. The generalized distribution and the mineral denseness of the deposits are elements in the diagnosis.

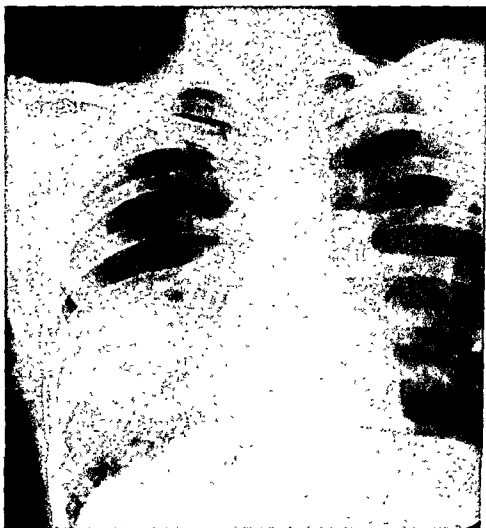


Fig. 22.—Lung abscess.

Cystic Disease of the Lung.—Congenital cyst formation in the lung has been frequently reported. There are two types, those containing fluid and those containing air. The fluid cysts may appear in the mediastinum or in the pleural cavity. They present smooth, well-defined, rounded, uniformly dense shadows about half the size of a lobe of the lung. Air cysts are rounded, well-defined, radiolucent areas devoid of lung markings. They occur usually in the upper lobes.

Secondary metastatic malignant deposits in the lung are characterized by shadows which are multiple, nodular, often star-shaped densities. They vary greatly in size, but usually are about the diameter of a dime or a quarter.

Diseases of the Pleura

Acute fibroplastic pleurisy does not show on the x-ray plate unless considerable thickening has occurred. Pleural thickening following inflammation produces hazy shadows, sometimes described as a fine ribbonlike shadow running along parallel to the chest wall on the outer border of the lung.

Fluid in the pleural cavity, whether effusion, empyema (pus), or transudate from cardiac failure presents characteristic x-ray signs.

Much misconception in these cases is due to failure to differentiate free fluids from fixed fluids and to recognize the pathologic varieties of these two forms of fluid. The mechanics of the fluid's presence depends entirely on whether you are dealing with one kind or the other. Englebach and Carman long ago published an article which was a clear-cut, splendid piece of clinical observation and yet textbook after textbook on physical diagnosis has been published or revised since its publication without a single reference to it. (Englebach and Carman: *X-ray Studies of Serofibrinous Pleuritis*, Am. J. M. Sc., Dec., 1911.) The work of Norris and Landis on frozen sections of cadavers dead of empyema is confirmatory of this work from a different angle.

Englebach and Carman were puzzled by certain x-ray plates in pleural effusion which showed a shadow that was upright when the patient was upright and in which one panel of the shadow was darker than the other. They pointed out that this was due to the fact that pleural effusion is almost always fixed and that it spreads out over the thoracic wall flattened by the pressure of the lungs. "The location of the fluid in sero-fibrinous pleurisy is xx, in the great majority of cases xx in the vertical position in the upright chest. Adhesions xx encapsulate the effusion."

Improvements in technical apparatus have permitted satisfactory depiction of the chest in lateral and oblique projections, thus offering much help in diagnosing interlobar exudates, location of empyema pockets, abscesses, etc. Small effusions will not be revealed by routine posteroanterior and lateral films. Study of the patient in the recumbent side positions, where fluids gravitate along the axillary gutter, will be necessary for these.

There are six kinds of fluid occurring in the pleural cavity:

FREE FLUIDS

1. Transudates, as in cardiac or renal disease.
2. Pyopneumothorax, or hydropneumothorax.
3. Hematothorax (usually free; usually following gunshot wounds).
4. Chylothorax (rare).

FIXED FLUIDS

5. Pleural effusion.

6. Inflammatory exudates, following lobar or bronchopneumonia, or other inflammatory processes in the lungs (empyema, and semiclear exudates, containing leucocytes).

The factors which influence the position and the outline of the pleural fluid are three:

1. The position of the inflammation in the underlying tissues, i.e., the lungs.
2. The pressure exerted by the lung, and the action of the diaphragm.
3. The position of the patient when the fluid forms.



Fig. 100.—The development of pleural fluid. Small amount of fluid forming in lower right costophrenic angle. Dullness was in back of chest only; in front the percussion note was resonant.

1. The position of the inflammation naturally determines very largely the localization of the fluid if pleuritis supervenes. Not always, however. Occasionally one will see lobar pneumonia in an upper lobe, and empyema in the axillary space or in the back. In pleural effusion too, the effusion usually occurs somewhere at the lower borders of the lungs, yet the tuberculous focus

beneath, whether it develops before or after the development of the effusion, is usually at an apex. Whether these things represent metastatic pleuritic infections or the gravitation of the fluid downward, it would be hard to say. However, the fluid sometimes accumulates over an upper lobe pneumonia, as in Fig. 2, previously mentioned. In the study of a series of sixty cases of



Fig. 101.—The development of pleural fluid. Later stage than shown in Fig. 102A, showing accumulation of more fluid.

empyema, fifty-six were in the lower part of the chest, most of them definitely back of the posterior axillary line. Of the preceding pneumonias, fifty-two had a posterior lobe involvement, either partially or entirely or with an upper lobe involvement also.

2. The pressure exerted by the lungs and diaphragm. The lungs act on any fluid which comes between the two surfaces of the pleura as an elastic

bag, which exerts a varying pressure during inspiration and expiration, but always exerts a pressure. This pressure is produced by the action of the diaphragm. If there is a heavy fluid present and the chest is in a more or less upright position, the fluid gravitates to the bottom of the chest cavity; this condition obtains in transudates. When fluid rises it does not, however, simply push the lung above it, it rises in the space between the visceral and parietal pleura. The upper level of the liquid does not always represent the lower level of the lung. In inflammatory exudates, such as precede the formation of

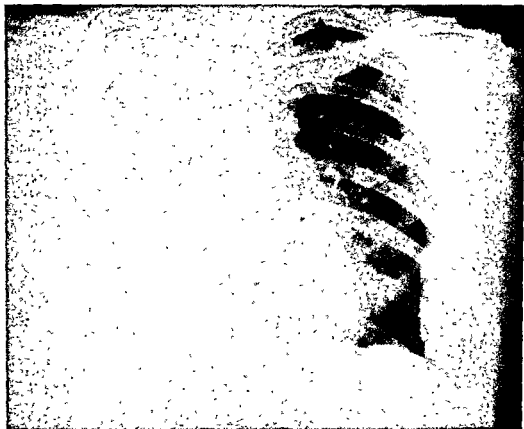


Fig. 102.—The development of pleural fluid. Still later stage. Fluid now fills entire back of chest.

pus, the lung presses them out in a thin layer over a larger surface than perhaps they would originally attain. At the borders of this fluid adhesions begin to form, aided by the pressure of the unaffected part of the lung. At the periphery of the effusion internal pressure forces the visceral and parietal pleura together, at which point conditions are ideal for the maximum production of adhesions. It is said, especially in empyema, that the diaphragm is paralyzed and remains motionless. Whether or not this is true and how early, it is certain that some modification of its motions does take place both in empyema and effusion on the affected side. This also helps to make the formation of adhesions more dense once they have become started.

3. The patient who has acquired an empyema has usually been on his back for a period of from ten days up, sometimes reclining and more often sitting in a half-reclining position. A glance at an eviscerated thorax shows that the most dependable part of the cavity is in the groove formed by the angle of

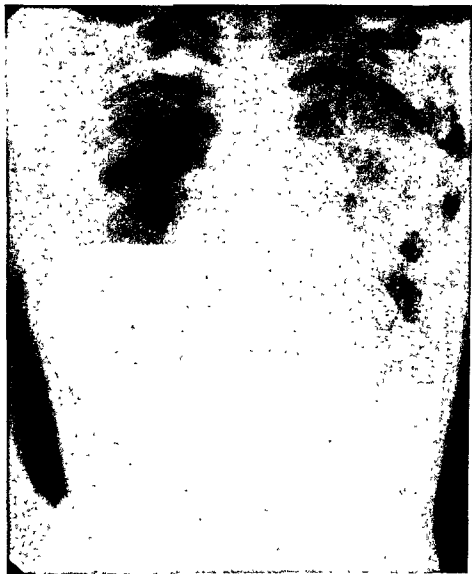


FIG. 163.—Fluid in the pleural cavity (right), showing upper line of level of the fluid. This occurs only when there is also a pneumothorax. The fluid moves on change of position of patient.

the ribs, which is situated just back of the posterior axillary line. It is in this groove that over 50 per cent of all empyemata form. It was the tabulation of this incidence of their presence which led to a study of the anatomy of the chest causing it. In a necropsy if any free fluid is left in the thorax it always

rests in this groove. Another frequent point of pus collection is close along the vertebral ridge, where the pressure of the lung is weakened by the projecting walls. (Clendening: J. Missouri M. A. 16: 287, Sept., 1919.)

Free fluids and movable fluids are seldom seen in the chest. (I mean as natural accumulations. The large number of cases of artificial pneumothorax has brought the incidence of movable fluids beyond that of fixed fluids.) The only condition that invariably produces freely movable fluid is an associated



Fig. 104.—Same patient as shown in Fig. 103, lying on left side. This shows change of fluid level on change of position of patient.

pneumothorax. Even transudate with the patient in the upright position is flattened out against the thoracic wall so that the upper level fades imperceptibly into clear lung markings. When the patient is put on his side, the fluid moves very slowly if at all and is quite as likely to flow over the top of the lung laterally as to gravitate down along the mediastinum.

That pleural effusions and empyemata are inflammatory fluids and create adhesions between the layers of the parietal and visceral pleura, explains many bizarre positions of these fluids seen on the x-ray plates. They may be held in

the upper part of the chest cavity with clear lung beneath, and as a thin strip either against the vertebral shadow or on the outer edge of the thorax.

Equally fallacious in roentgen interpretation is to depend for positive diagnosis on displacement of the heart by the fluid. This rarely occurs. It is more likely with free fluids; with fixed fluids it is extremely rare. Yet so



Fig. 105.—Hydrothorax. Patient lying on right side. This shows that the fluid does not always shift in accordance with gravitation.

blind are clinicians and roentgenologists to this fact, so enclosed are they by habit, that I have seen in a published article the x-ray picture of a chest with pleural fluid where the legend called particular attention to the displacement of the heart, and where no displacement could be seen at all!

Interlobar empyema occurs usually on the right side in the pleural space between the upper lobe above and the middle and lower lobe together below. The plane of this surface runs obliquely from about the second or third rib behind to the fourth or fifth rib in front, and the shadow thrown by the x-ray is consequently broad and may deceive the observer into the interpretation of an encapsulated collection of fluid flat against the chest wall. (Fig. 107.) Tuberculosis frequently produced such an interlobar exudate.



Fig. 106.—Fluid in pleural cavity. Empyema right upper chest. Notice that it is held in place by adhesions.

The condition most commonly imitating pleural fluid is atelectasis of one lobe. Pneumonia shadows sometimes resemble pleural fluid.

Endothelioma of the pleura, a very rare lesion, and questioned as an entity by some pathologists, produces a dark shadow, resembling fluid, on the x-ray plate. Sarcoma of the pleura is even rarer. The Pancoast tumor arises from the chest wall and projects into the thoracic cavity, but as it is of about the same density as the intrathoracic structures, it often cannot be discerned. It is recognized by the destruction of the ribs.



FIG. 107.—Pleural fluid. Interlobar empyema.

Diseases of the Mediastinum

The mediastinum is often spoken of as if it were a structure. As a matter of fact it is simply a locality. It is that part of the thoracic cavity between the sternum, the vertebrae, and the inner borders of the lungs. It has been divided by anatomists into four parts: the superior, anterior, median, and posterior mediastinum. The superior mediastinum, the part which is clinically most frequently interesting, lies above the pericardium. The anterior mediastinum is that part between the pericardium and the inside of the sternum, while the median and posterior mediastinum are respectively the parts between the layers of the pericardium, and between the pericardium and the inside of the vertebral column.

The superior mediastinum contains the following structures: (1) the trachea, and part of the primary bronchi after their division, (2) the arch of the aorta, (3) certain large arteries—the innominate, the left common carotid, and the left subclavian, as well as some smaller ones, (4) veins—the superior vena cava, and the innominate, (5) certain nerves, the phrenic, pneumogastric, and recurrent laryngeal among them, (6) the esophagus, (7) the thoracic duct, (8) numerous lymph glands, largely on the right side and near the right primary bronchus, and (9) the thymus gland in childhood, and its remains in adult life. All of these structures are in such relation that disease of one is likely to affect the others.

The pathologic changes in the mediastinum have been classified by Lemon (M. Clin. North America 5: No. 3, Nov., 1919) thus (slightly modified):

1. Benign neoplasms. Rare. Chondroma (from the second rib) and dermoid cysts are described. Mix (M. Clin. North America 3: No. 6, May, 1920) mentioned also fibromata and lipomata.

2. Malignant neoplasms—primary or secondary. Sarcoma and carcinoma.

3. Abnormally placed organs:

a. Substernal goiter.

b. Enlarged thymus.

4. Hodgkin's disease.

5. Lymphoma. Lymphosarcoma. Lymphatic leucemia. Lymphosarcoma is the commonest of mediastinal neoplasms.

6. Tuberculosis.

7. Pott's disease—especially with mediastinal abscess extension.

8. Pathologic conditions in the circulatory system:

a. Aneurysm.

b. Aortitis.

c. Dilatation of the aorta from high pressure.

d. Mitral stenosis.

e. Cardiac hypertrophy, especially with aortic insufficiency.

f. Pericarditis with effusion.

9. Syphilis.

a. Gumma.

b. Syphilitic mediastinitis.

10. Actinomycosis—very rare.

11. Nonspecific mediastinitis—in influenza, measles, etc.

The symptoms and signs which these growing masses cause have been discussed in the chapter on physical diagnosis. Of roentgenologic interest beside the shadow of the tumor itself are displacement of the trachea, displacement of the esophagus, atelectasis of a lobe of a lung from pressure of a bronchus, pressure disease of the vertebrae, or sternum, and unilateral paralysis of the diaphragm from pressure on the phrenic nerve.

The most frequent mediastinal tumor, which compresses the trachea, is aneurysm. In the radiograph of one such case the distortion and narrowing of the trachea can be plainly seen. It is well to remember that these cases may present themselves simply as asthma, and the superficial manifestations of them be indistinguishable from a typical bronchial asthma. During my service as intern at the Augustana Hospital in Chicago, a man was brought in one hot summer night, with a characteristic spasm of asthma—the first he had ever had. It was before the days of routine radiographs of the chest, and on physical examination, next day, by the chief of service, no finding beyond lung changes was made out. Forty-eight hours later the patient had a sudden hemorrhage into the throat and died. At autopsy an aneurysm of the transverse arch was found, compressing the trachea down to a slit hardly large enough to admit a dollar.

The appearance of an enlarged thymus is quite characteristic. The thymus attains its maximum growth at the age of two years. It occupies the superior and anterior mediastinal spaces. At puberty it rapidly diminishes in size so that it remains, in adult life, a fibrous strand usually attached to the thyroid. "Thymic asthma" from pressure of the gland on the trachea is a condition which, while not common, has nevertheless frequently been described. Chevalier Jackson has observed with the bronchoscope the compression of the trachea due to enlarged thymus. Crotti (J. A. M. A. 60: No. 8, Feb. 22, 1913) has pictured the narrowed trachea in one of his cases. As is well known, the condition may come on very suddenly and cause death—the sudden death of status lymphaticus, of which enlarged thymus is a part. Sudden death in infants variously ascribed to such causes as having the mother roll on the baby, the cat sucking the baby's breath, etc., may be due to enlarged thymus. (Clendening: J. Missouri M. A. 19: 68, Feb., 1922.)

OBLIQUE AND LATERAL X-RAY FILMS OF THE THORAX

Lateral and oblique views of the thorax are largely valuable for revealing the posterior mediastinum. In studying the esophagus they are mandatory. They reveal aneurysms that at times cannot be seen in the anteroposterior position. The descending aorta is the portion most often involved in arteriosclerotic and calcareous change, and it can hardly be seen at all in the conventional anteroposterior film. The oblique view may show astonishing tortuosity and lengthening which explains many of these patient's symptoms and may throw light on attacks simulating angina. Calcification of the descending aorta may also be observed.

But on the whole, in my experience at least, little has been gained in most diagnostic problems by the use of the oblique or lateral position. In most films interpretation is difficult and the shadows are confusing. In only a small minority is the clinician rewarded with anything positive. In hospitals where they are not taken as a routine, the clinician may comfort himself by the knowledge that little is lost.

This view is not entirely in accord with some orthodox pronouncements and in order to be entirely fair I quote the words of my late friend, Dr. J. S. Pritchard, of Battle Creek (*Arch. Surg.* 10: 557-566, Jan., 1925):

"What information may be obtained from an oblique roentgen-ray study of the thorax?"

- "1. The location and estimation of the extent of substernal enlargement.*
 - "2. The location and outline of mediastinal tumors.*
 - "3. The size and outline of the glandular tissue (bronchial and thymus).*
 - "4. The location of foreign bodies of a certain type.*
 - "5. The outline of the exact course of the trachea with the detection of any irregularity in its size, shape, or position.*
 - "6. The condition of the thoracic spine.*
 - "7. An estimation of the size, shape and density of any part or parts of the thoracic circulatory system.*
 - "8. The condition of the diaphragm and the location of posteriorly formed pleuropericardial or spinal pericardial adhesions.*
 - "9. The location and outline of pulmonary suppurations (the patient lying on the side).*
 - "10. The behavior of the 'barium mixture' in its passage through the esophagus.*
 - "11. The location of calcareous deposits, such as calcified glands, below but within the circle of the aortic arch. These conditions sometimes cause pain simulating that caused by angina pectoris.*
- "What is the method of procedure in the study of the posterior mediastinum?"*
- "The history taking, a physical examination, and the roentgen-ray study. The latter method must be relied on to give the most valuable information. In studies of the oblique position, the fluoroscope will not reveal all that the roentgenogram can visualize and should not be relied on except as a registrar of movement, such as the abnormal contours of an adherent diaphragm during deep inspiration. The passage of an opaque diagnostic medium, like barium, down to the esophagus is another example."*

After reading a draft of this x-ray section Dr. Milton J. Geyman, of Santa Barbara, California, objected to the minimizing of lateral and oblique positions for roentgen chest studies and wrote as follows:

"The positions you mention are extremely valuable and not difficult to interpret if properly made. A patient with an apparent lung infiltration cannot be considered as properly studied without supplemental films to the conventional posteroanterior projection."

The Diaphragm

Before the development of good chest x-ray, there was no such thing as clinical diagnosis of diseases of the diaphragm. Every once in a while some desperate clinician would feel that he would appear very profound if he read a paper on diaphragmatic pleurisy, and every once in a while a diaphragmatic

hernia would be found at autopsy or even diagnosed and operated upon during life, but these left no organized science of diaphragmatic diagnosis.

The diaphragm, according to Baldwin Lucké (*On the Morbid Anatomy of the Diaphragm*, *Ann. Int. Med.* 5: No. 6, Dec., 1931), is probably the most interesting and important of the skeletal muscles. Its physiologic properties are unique (Lee, Guenther and Meleney: *Am. J. Physiol.* 40: 446-473, 1916). It is the chief muscle of respiration. It is an important aid to the circulation, especially the venous circulation, in an erect animal. It is seldom the primary seat of disease, but secondary disease from lung, pericardium, gall bladder and peritoneum frequently affect it. Primary tumors are rare; while secondary tumors are very common; carcinoma, sarcoma, and hypernephroma may even be said to elect it. Tuberculosis secondary to pulmonary tuberculosis occurs. Diaphragmitis occurs as a sequel to pneumonia. Trichinosis is, of course, notoriously likely to find the diaphragm. Zenker's hyaline degeneration occurs as a sequel of pneumonia. (See Wells, H. G.: *Waxy Degeneration; a Factor in Causing Death in Pneumonia and Other Conditions*, *Arch. Path.* 4: 681-686, 1927.) Many of these conditions incapacitate the diaphragm very seriously, and the incapacity can be seen under the fluoroscope.

Diaphragmatic Adhesions.—Many forms of infection invade the pleural surface of the diaphragm, causing adhesions and disturbing the smooth contour of the diaphragmatic shadow. There are numerous sharp upward projections—"tenting of the diaphragm." (Matson: *Diaphragm Irregularities*, *Am. J. M. Sc.* 163: No. 6, June, 1922.)

Scalloping of the diaphragm is a disturbance of the smooth contour of the diaphragm in the form of sharp downward projections which mark it off into a series of rounded scallops. It is presumed that this is due to the projection of large bronchi rendered stiff by fibrosis.

Immobilization of the diaphragm may occur as a splitting action from acute inflammation of the lungs or pleura above or of the peritoneum beneath.

Subphrenic Abscess.—Any intra-abdominal infection may extend, by following the cleavage lines of the peritoneal folds between loops of adhesions, into the spaces between the liver and the diaphragm on the right, and between the fundus of the stomach and the diaphragm on the left. The most frequent cause is suppurative appendicitis. Perforated gastric or duodenal ulcer is the next most frequent cause; cholecystitis is third in frequency. The diagnosis depends more on the history and physical signs than on the x-ray signs. (See Chap. 9, p. 433.) The x-ray picture aids in the diagnosis by indication of the position and immobility of the diaphragm. In cases in which a peritoneal-pleural-bronchial fistula has occurred, the shadow indicates the route of the fistulous tract: the chest on the affected side is constricted, with narrowing of the intercostal spaces.

Diaphragmatic Hernia and Hiatus Hernia.—The most important practical contributions of the x-ray to clinical pathology of this region has been the development of our knowledge of the various forms of diaphragmatic hernia and the so-called hiatus hernias.

There are six weak spots in the diaphragm: the esophageal opening (the most frequently involved in hernia), the aortic opening, the vena cava opening, the foramen of Morgagni, at the attachment of the sternum, and the pleuroperitoneal hiatus of Bochdalek, one on each side, at the posterior attachment exactly in the midline of each thorax (the line of the vertebral border of the scapula).

Marks (Am. J. Roentgenol. 37: 613, 1937) has made the practical classification of diaphragmatic hernia:

1. Thoracic stomach. Esophagus. Esophagus very short. Entric stomach in the thorax above the diaphragm.
2. Diaphragmatic hernia with short esophagus. Part of the stomach above the diaphragm with a congenitally short esophagus.
3. Hiatus hernia—esophagus of normal length. (1) Esophagus not forming part of the hernia—para-esophageal. (2) Esophagus forming part of the hernia.
4. Congenital hernia. Other parts of the gastrointestinal tract are usually involved—the colon and small intestine. Most common through the foramen of Morgagni or Bochdalek.
5. Traumatic hernia.
6. Congenital absence of the diaphragm.

Traumatic hernia and congenital absence of the diaphragm need little comment. The diagnosis of traumatic hernia has been made fairly simple by the employment of the x-ray, provided one remembers that trauma followed by dyspnea, difficulties of deglutition, upper abdominal and thoracic pain, possibly vomiting may be a diaphragmatic hernia. Sometimes slight trauma may result in hernia.

Thoracic stomach is a very rare condition, and since it gives rise to very few symptoms, it is usually discovered accidentally. Most patients reported are beyond the age of seventy.

Short esophagus and hiatus hernia differ in their anatomy, but form a continuous series from the point of symptoms. The essential feature is the cardia above the diaphragm and the relaxation of the diaphragmatic esophageal sphincter. Dysphagia, relieved by vomiting, regurgitation (Arnold, in 1838, reported three cases of "human ruminants"), pain at the ensiform, with dyspnea and even cyanosis after eating, imitation of ulcer, gall bladder or anginal syndromes all point the way to an x-ray examination. The chief obstacle to the diagnosis of diaphragmatic hernia is to neglect to look for it. When present it is usually easy to make out the anatomic varieties—short esophagus, para-esophageal or esophageal and cardia hernias.

(Good general articles on diaphragmatic hernia are those of Myers: J. A. M. A. 31: No. 11, p. 428; and Root and Pritchett: Cleveland Clin. Quart. 5: No. 3, July, 1938.)

Eventration of the diaphragm is chronic relaxation of the diaphragm inasmuch as its whole side is flaccid and highly domed as a rule, though it may be reversed. It seems to be due to neuromuscular changes. It is congenital,

which may be asymptomatic as the individual reaches adult life. Often the subject is a blue baby with attacks of dysphagia and dyspnea which carry it off in infancy.

IV. X-RAY DIAGNOSIS OF DISEASES OF THE DIGESTIVE SYSTEM

A. Teeth

The greatest service the consulting internist can render in the field of the teeth is to prevent drastic operations and drastic mechanical procedures. A good dentist is essentially a good mechanic. And a good mechanic likes toys. And the x-ray machine is a toy. Dentists are inclined to pay entirely too much attention to the deviations from a theoretical normal which it reveals. Few orthodontists, for instance, would care to hear the opinion of the average internist on the value of his expensive mechanic device.

The pediatrician should send his patients early to the dentist: this is becoming more generally recognized. It is evident that deciduous teeth serve a very definite purpose and should be preserved in good health until they are lost through normal exfoliation. The pediatrician and dentist can be of great assistance to each other in studying the general health problem and its relation to caries and the necessity for orthodontic intervention.

He should insist on at least one pair of well-taken bitewing x-ray films, plus transillumination of the entire mouth, twice a year. In this inexpensive manner cavities can be located while still small. Hence, if those cavities are properly filled and regularly inspected, aching teeth, abscesses, and extractions can be reduced to a minimum in adult life.

He should make two further demands on the dentist: first, that the dentist instruct the child personally in the use of the tooth brush; and, second, that he report to the internist any new, rapid, or extensive increases in dental caries, these latter being among the first diagnostic signs throughout the body to give evidence of certain glandular or nutritional deficiencies.

With the advance into youth the steady use of bitewing x-ray films and transillumination should not be diminished. Rather it should be maintained and supplemented at intervals with a complete set of dental x-ray pictures, requiring approximately sixteen exposures. These latter show the root ends of teeth, infected teeth, abscesses (which should never be present in the mouth which has been cared for from infancy as described above), and any other abnormalities.

Throughout the years until death, bitewing x-ray pictures and transillumination with the mouth lamp should be regarded as the absolutely minimum aids in diagnosis for every patient regardless of financial means. As a minimum also, individual x-ray pictures should be taken of any teeth suspected of being nonvital or impacted.

Edentulous spaces should be x-rayed as thoroughly as those with teeth remaining. All too frequently a broad expanse of healthy gum will conceal broken and abscessed roots or unerupted teeth. This is true even though for

years a patient may have worn a full denture. It then becomes the duty of the internist and dentist to decide whether the surgical removal of such residue will be justified, age, health, severity of ordeal, etc., all being considered.

Three general sets of conditions in the teeth may require the active consultation of the internist and the dentist.

1. Infection or disease which may have constitutional effects on the whole body.
2. Diet deficiencies or glandular dysfunctions, manifested in rampant decay or pyorrhea.
3. Conditions which may result in local symptoms—headache or neuralgia of dental origin.

APPEARANCE OF THE NORMAL STRUCTURE OF THE TEETH ON THE X-RAY PLATE

A normal tooth is constructed as follows: the main mass of the tooth is dentine (ivory is elephant's dentine). This is hard and tough in consistency. Within this, running as a central pipeline, is the pulp, filled largely with blood vessels and nerve tissue. This slender mass is less dense than is the dentine. *The extremely hard, glossy veneer covering the dentine, that which we see in looking at a tooth, is the enamel. It is of greater density than dentine.*

These three densities will naturally show in the roentgen negatives as follows: the denser enamel lightest, the dentine darker, and the pulp canal darkest.

The enamel which covers the crown portion of the tooth, will vary in thickness, from $\frac{1}{4}$ mm. to $1\frac{1}{2}$ mm. On the root portion of the tooth there is likewise a veneering, called the cementum. This, however, is so microscopic in thickness that it is not revealed in the x-ray film. The purpose of the cementum is to attach the tooth to the peridental membrane and hence to its supporting bone.

A tooth is set in bone much the same as a post or pole is set in the soil. However, with the tooth there is a cushion of connective tissue surrounding the root which ties it to the wall of its bony socket. This is called the peridental membrane. Being of connective tissue it will show darker in the x-ray picture than does the dentine.

Carrying further the comparison of the root of the tooth and a pole set in the soil, there can be visualized such a post, say a telephone pole, encased in a stocking of rubber before its embedment. This elastic veneer will accommodate the pole to shock, serving as a complete but thin cushion.

Similarly the peridental membrane serves as an unbroken cushioning attachment. The peridental membrane is among the most important of the dental structures radiographically and therefore should be clearly visualized.

Let us carry the comparison of the tooth and the telephone pole one step further. Before that pole was set, the waiting hole in the soil was thinly lined with concrete. With the pole in place there then exists the following: the pole, encased in its rubber veneer, in turn encased in a thin denser veneer of

(2) **Fibrous type**—fibrous connective tissue cells and granulation tissue predominate, which show on the roentgenogram as a definite radiolucent area without the presence of a white line. They are slow growing and do not indicate so virulent a process as the epithelial type, but at any time may become activated and then acquire the epithelial characteristics.

(3) **Chronic alveolar abscess type**—characterized by the presence of polymorphonuclear cells with formation of pus and resorption of the end of the infected roots. This rarefied area is usually walled in by condensed bone.

(4) **Diffusing rarefying osteitis type**—has no definite outline, but blends with the surrounding bone. This type of lesion indicates low local resistance of the bone, low general resistance, or high virulence of the bacteria. The surgical management of these cases calls for the exercise of caution and considered judgment.

Whether one entirely agrees with this latter classification or can feel certain that he can distinguish the epithelial from the fibrous type of lesion on the x-ray plate, it is certainly necessary for the consultant to keep in mind the factors of virulence of invader and resistance of the host.

Periodontal infections on the side of the root instead of at the end (periapical infections) may occur.

Other changes that may occur as a result of chronic root infection include *hypercementosis*, an excessive deposit of cementum either along the entire root of the tooth or in the apical region. This, like pulp stone formation, may indicate a general systemic condition, not necessarily infectious. Bulbous enlargements of the apices, especially of the molars, indicate *hypercementosis*. *Cementoma*, which is a localized osteitis fibrosa at a tooth root, resembles on the x-ray plate a granuloma, but may be differentiated because it is x-ray lighter by the fact that the tooth involved is vital as shown by pulp tests. Pathologically there is bone destruction and replacement by fibrous tissue.

The pulpless tooth is a problem which has given rise to some difference of opinion. The older idea was that a pulpless tooth is always infected and a source of focal absorption. The most conservative dental opinion at the present time inclines to believe that this is not necessarily true. Bunting and Hill (*A Textbook of Oral Pathology*, ed. 2, Lea & Febiger, 1940) write:

"It is a very curious fact that the dental pulp which is a formative and nutritive organ of the tooth may die and undergo various necrotic changes or may be surgically removed and the tooth to which it bore so intimate a relationship may remain almost unaffected by the loss of its vital organ. This is most unusual, for in all other parts of the body the cutting off of nutrition from an organ or tissue results in death of the part and distinctive reactions in the surrounding tissues. These may consist of active protection processes, such as sequestration or exuviation of the affected area, or the contiguous tissues may undergo progressive necrosis. The pulp of the tooth, however, may die without producing any apparent change in the surrounding dentin and enamel other than a slight diminution of their strength and resistance to physical stresses. The hard substances of the tooth may fulfill their normal function and endure ordinary strains incident to mastication for many years after the death and removal of the pulp. The important difference between

the dental pulp and other tissues is that the pulp bears but slight anatomic relationship to any tissue other than the dentin and enamel of the tooth. The relationship of the tooth to the surrounding tissues is dependent not on the pulp but on the periodontal membrane. The pulp may die or be removed surgically and, if the periodontal membrane is not injured or invaded by infectious organisms, the original status of the tooth and its relationship to the surrounding parts is not changed other than by the formation of a small amount of scar tissue at the point of severance of the pulpal vessels in the apical foramina. However, if the periapical tissues are injured by trauma through instrumentation, by drugs, or by bacterial and toxic products of pulp decomposition, a portion of the periodontal membrane may become necrotic and the tooth at that point becomes a foreign body which is incompatible to the surrounding tissues. Although the dentin and enamel are deprived of their nutrition and are devital, the status of the pulpless tooth and its relationship to the surrounding tissues are unchanged unless necrotic processes subsequently occur in the periodontal membrane."

Pyorrhea is indicated roentgenologically by thickening of the periodontal membrane as well as by alveolar absorption at the gingival margins of the teeth. Progressively the infection involves the portions of bone between the roots of the teeth and when this occurs the teeth involved cannot be saved.

Purely local abnormalities which may be associated with pain, neuralgia, or headache include:

Pulpstones, which appear as small smooth-walled, round, or oblong shadows in the pulp canal. They are usually physiologic due to secondary dentine formation. Their principal significance is that they are too often pointed out as the cause of a neuralgia or headache in a neurotic patient and the tooth sacrificed as a consequence of the finding.

Impacted or Unerupted Teeth.—The third molar is naturally enough most often involved in this way. It may impinge on the second molar and interfere considerably with normal development. In fact it often threatens the destruction of the second molar. Symptoms of trifacial neuralgia and eustachian tube irritation or compression may result. This, however, is the supreme example of the case where the personality of the patient must be considered in connection with the symptoms and the possible relationship of the pathologic condition to them. The symptoms and the pathology should be very logically associated and correlated before the extensive surgery often involved in third molar extraction is to be recommended.

Small fragments of tooth root left behind after extraction or fracture. Even in presumably edentulous mouths these may occur. They may undergo so much lime absorption that special technique is necessary to distinguish them roentgenologically.

An infected tooth root may communicate with the maxillary sinus.

Dentigerous cysts, odontomata and other neoplasms of the jaw occasionally fall within the field of the consulting internist.

Adamantinomata are epithelial remains of the enamel organ. They are quite cellular histologically, and the cells are embryonal in appearance. "The gross appearance is that of a meaty or multilocular growth inclosed within a

thin parchment-like bony capsule." (Padgett and Soderberg: *Adamantinomas of the Jaw*, J. Missouri M. A. 38: No. 8, Aug., 1941.)

Dentigerous (follicular) cysts are often associated with unerupted or impacted teeth. The third molar, cuspid, and premolar regions are most frequently involved. They grow slowly and as they grow, bone is destroyed, but regardless of the size they attain they are covered with a thin plate of bone which on pressure causes crepitation. Their origin is in the degeneration of the ameloblastic layer of the enamel follicle and the accumulation of cystic fluid within the central portion of the follicle.

Odontomata are solid tumors composed of all tooth elements—dentine, cementum, enamel, etc. They arise as a disturbance of the dental follicle during the formation of the tooth. They are grouped into enamelomata, dentinomata, cementomata, and mixed odontomata. Cementomata, which are the commonest, form on the tooth roots, attaining considerable size. They occupy a position midway between benign and malignant tumors in that they are invasive locally, but only very rarely metastasize. They are troublesome from the surgical standpoint because they tend to recur unless widely removed. They are tumors of early adult life (10 to 35 years) and grow slowly and uninterruptedly for many years. Pain occurs only with infection or nerve impingement. The only signs are expansion and distortion of the contour. The surface is bosselated and the overlying bone gives a sense of resilience on pressure. They occur most frequently in the lower jaw at the angle. Rapid expansion follows rupture of the capsule. The x-ray negative is usually quite characteristic. The delineation of the walls is rather sharp, with multilocular contents and possibly bony trabeculae.

Neuralgia of Dental Origin.—The maxillary nerve, the second division of the fifth cranial nerve, is entirely sensory. Its terminal branches spread out on the side of the nose, lower eyelid, and upper lip. Before and during its passage in the infra-orbital canal it gives rise to three branches supplying the teeth and soft tissues of the buccal mucosa. The relation of neuralgia of this nerve and disease of the teeth is naturally often brought up. Undoubtedly many dental conditions do cause such neuralgia, but equally undoubtedly it is easy to sacrifice good teeth in a blind attempt to relieve such neuralgia.

One of the most necessary warnings is against wholesale removal of teeth for tic douloureux. Every neurologic surgeon sees hundreds of pitiful examples of such sacrifice, where the poor victims are sans teeth necessary for their nutrition and comfort, and still have the neuralgia.

The association of unerupted teeth with neuralgia is another combination which must be regarded with critical appraisal, as indicated above under unerupted teeth. There are many cases of relief of neuralgia from extraction of unerupted teeth, but equally large numbers of cases in which no relief occurred. Sometimes when neuralgia persists after removal of an unerupted tooth, an x-ray picture will reveal a retained root in contact with the mandibular canal, removal of which will result in relief.

Pulpstones are frequently implicated in neuralgia and headache, but a connection is difficult to establish in view of the frequent occurrence of pulpstones which produce no symptoms at all.

Costen, in a valuable series of reports, has pointed out a syndrome of headache, earache, partial deafness, and faceache due to badly fitting dentures or maladjustment of the temporomandibular articulations as a result of removal of lower teeth. (Costen: *Neuralgias and Ear Symptoms Associated With Disturbed Function of the Temporomandibular Joint*, J. A. M. A. 107: 252, July 25, 1936.)

Headache of dental origin is an even more difficult and involved problem. In general, I believe that headaches can very seldom be laid to dental disease. At any rate in either neuralgia or headache, if teeth are to be removed or dental surgery employed the internist should be satisfied that the teeth are really diseased anyway.

(See also Main: *Nerve Reflex Disturbances of Dental Origin*, J. Am. Dent. Assn. 20: 870, May, 1933; Brashers: *The Innervation of Teeth*, J. Comp. Neurol. 61: 169, April, 1936; and Resch: *Neuralgia of Dental Origin*, Cleveland Clin. Quart.)

B. The Esophagus

The observations made by means of x-rays with both fluoroscopy and plate with barium meal technique may be said to have created the science of the clinical pathology of the esophagus. In all cases of suspected esophageal disease the x-ray examination is the most important part of the diagnosis; in most it is the only diagnostic procedure that need be employed.

There are few symptoms that call for esophageal exploration: none is obscure, and all are sufficiently uncomfortable to force themselves on the patient's attention and urge him to seek relief. Few cases of esophageal disease, therefore, need go unobserved. The symptoms are difficult and/or pain on swallowing, regurgitation of food, and a feeling of pressure at the cardia.

The normal adult esophagus is about 25 cm. long. The act of swallowing begins with a remarkable coordinated reflex. The bolus of food is forced into the back of the fauces and then simultaneously the tongue elevates and pushes it into the pharyngeal pouch, the mylohyoid and hyoglossi muscles shoot it into the esophagus while the larynx is closed by the approximation of the vocal cords and the protective downward movement of the epiglottis, and the soft palate closes the opening into the nasal cavity. The entire action is performed in less than a second. The passage of food into the stomach after it has once entered the esophagus is engineered with equal expedition. Liquid food makes the passage in about 0.1 second. A bolus of solid food normally required about 6 seconds for passage from pharynx to cardia (Kronacher and Meltzer). The esophagus acts partly by peristalsis. The muscles of the upper part of the esophagus are striated, gradually merging into unstriated muscle.

There are four areas of physiologic constriction in the esophagus: (1) at the level of the cricoid cartilage; (2) at the transverse aorta; (3) at the pri-

mary bronchus; and (4) at the hiatus of the diaphragm. A good part of the six seconds required for the arrival of a bolus of solid food in the stomach from its start in the pharynx is spent at the cardia. The cardiac sphincter has its own intrinsic musculature and is independent of the action of the diaphragmatic muscle: this can be seen in cases of short esophagus (vide infra) and thoracic stomach where the cardia muscle is above the diaphragm and independent of it. The diaphragm, however, undoubtedly plays some part in the contraction of the cardiac opening into the stomach.

The diseases of the esophagus may be classified thus:

1. Diverticulum.
2. Foreign bodies.
3. Tumors.
 - a. Benign—papilloma, fibroma, myoma, leiomyoma, lymphangioma, polyp, angina.
 - b. Malignant—scirrhous and adenocarcinoma, sarcoma.
4. Stricture.
 - a. Congenital stricture or atresia.
 - b. Traumatic, chemical, and corrosive.
 - c. Neoplastic in origin.
 - d. Cardiospasm.
5. Varices.
6. Short esophagus—thoracic stomach.
7. Esophagitis. Inflammation. Syphilis. Tuberculosis.
8. Peptic ulcer of the esophagus.
9. Compression or distortion of the esophagus by other organs.
10. Miscellaneous causes of esophageal abnormality. Esophageal-respiratory fistula. Esophageal-pericardial fistula. Abnormal twisting volvulus (Mosher: Arch. Otolaryng. 18: 563, 1933). Cardioresophageal regurgitation. Spasm, atony, and paralysis of the esophagus. Plummer-Vinson syndrome (Dysphagia in Anemic Women, Minnesota Med. 5: 107, 1922). Edema of the esophagus.

1. Diverticulum of the Esophagus.—Pharyngeal pouches. MacMillan (J. A. M. A. 98: 964, March, 19, 1932) found that 2 per cent of pharyngeal pouches and 1 per cent of esophageal pouches were the cause of dysphagia in an examination of 1,000 patients presenting that symptom. Congenital diverticula are rare. Bronchial cleft diverticulum is a possibility. The commonest forms have been called pulsion and traction diverticula. Pulsion diverticulum occurs more often in the pharynx than in the esophagus: it is caused by pressure from within, perhaps by hastily swallowing large masses of food, combined with a weakness in the muscular wall of the pharynx. It usually lies on the left side of the esophagus, and can easily be made out on x-ray examination; it presents a fluid level and an air bubble. Once formed it tends to become larger, and may become large enough to hang down and obstruct the esophagus. Because these diverticula were described first by Zenker, they are called "Zenker pouches." Traction diverticulum is caused by adhesions pulling the walls of the esophagus from without. Infected mediastinal glands are commonly the origin of the adhesions. They are smaller than the Zenker pouches and sometimes have a tentlike appearance.

2. Foreign bodies are usually lodged at the suprasternal notch. When opaque (chicken bones, buttons, etc.) they can readily be demonstrated on the

x-ray plate. When nonopaque, many foreign bodies, including masses of food, can be shown both fluoroscopically and radiographically in the right oblique projection with the patient vertical, after the patient has swallowed a thin barium mixture. Careful roentgen studies are necessary to show small nonopaque bodies, and it is of great importance that a diagnosis be made as soon as possible after the swallowing difficulty.



Fig. 108.—Diverticulum of esophagus

3. Tumors.—Benign tumors are of extreme rarity. Carcinoma is suspected when the x-ray examination shows an irregular contour of the esophagus, reduction or absence of peristalsis, and narrowing of the lumen. Some dilatation of the esophagus above the obstruction is likely. Any part of the esophagus may be affected, though there is some predilection for the cardia region.

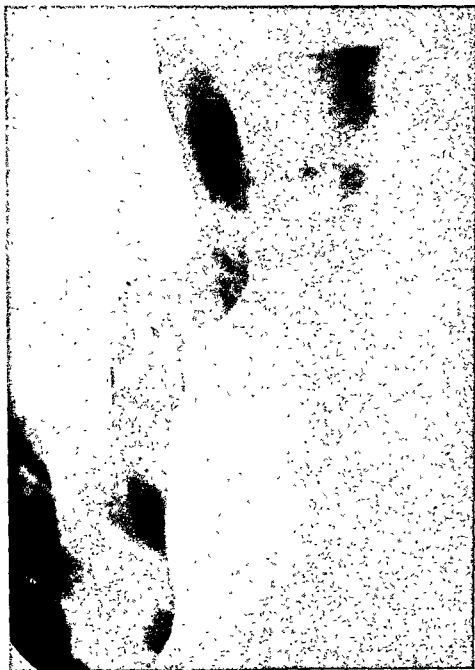


Fig. 109.—Cancer of the esophagus.

Perforation into the mediastinum or trachea is possible. Sarcoma of the esophagus has seldom been reported. Hacker and Lotheissen, in 1926, stated that there were 26 cases in the literature, some doubtful. It, however, has no characteristic roentgen diagnostic points.

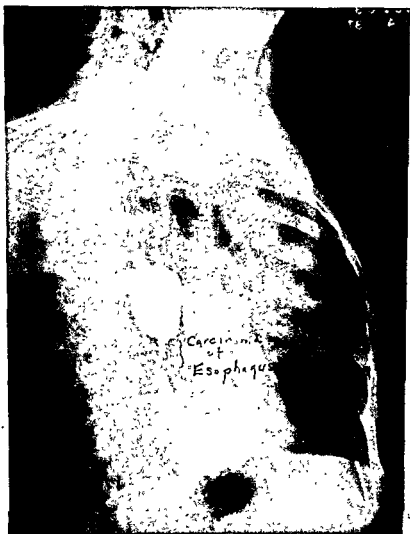


Fig. 110.—Carcinoma of esophagus.

4. **Stricture.**—Congenital stricture may give no symptoms until the end of the first year, or whenever semisolid food is first given. The types as given by Ballantyne (*Manual of Antenatal Pathology and Hygiene*, Wm. Wood & Co., 1905) are:

Atresia, or complete absence of the esophagus, its place being taken by a thin band of muscular tissue stretching from the pharynx to the cardiac end of the stomach.

Termination of the esophagus in a cul-de-sac.

Tracheo-esophageal fistula.

Membranous obstruction of the esophagus. Web or diaphragm formation. (Abel: Brit. M. J. 94: 1928.)

Simple narrowing—multiple or single.

Double esophagus.

The x-ray diagnosis of these should be immediately apparent.

Cicatricial stricture from swallowing lye or scalding water is recognized on the x-ray plate by a stiff-walled, evenly narrowed lumen with varying degrees of dilatation above it.

Cardiospasm. This remarkable and obscure condition has had the names *preventriculosis* and (by Hurst) *achalasia* suggested for it with, it seems to me, very little reason. *Cardiospasm* describes it exactly so far as we know about it—a functional spasm with no organic stricture. The cause of the spasm is unknown. It may be reflex due to abdominal disease, such as cholecystitis, or to ulcer of the esophagus in the cardia. The patients are not hysterical or neurotic. Hurst, in arguing for renaming it *achalasia*, stated that degenerative changes were found in the ganglion cells of Auerbach's plexus. According to many students the condition is not due to spasm of the cardiac sphincter (or/and the diaphragm) but to dilatation of the esophagus. Rolleston's case, which came to autopsy, occurred in a boy eight years old, following an attack of whooping cough. The esophagus was remarkably distended (nine and a half inches long) and pursued a tortuous course through the thorax. Fluid food was present in the esophagus at autopsy. There was no stricture to the cardia, and a finger could be passed from the stomach into the esophagus. Those who favor the dilatation explanation point out that there is no hypertrophy of the cardiac sphincter as there should be if the muscle had been in spasm. This explanation does not, however, comprehend certain mechanical features. Why shouldn't the food mass, which certainly becomes very heavy, pass into the stomach by gravity if there is nothing but dilatation without obstructive spasm of the cardia? And certainly in the x-ray picture the obstruction in the cardiac region is perfectly plain. Besides, every roentgenologist must have seen the spasm suddenly relax and the food mass pass into the stomach. Hypodermic injection of atropine will allow the meal to enter the stomach.

The x-ray appearance of cardiospasm is most characteristic. The first part of the barium meal goes down to the cardia and then stops and the following parts of the meal fill up the esophagus until it is enormously dilated. A fluid level can usually be seen. This dilatation is undoubtedly progressive, but by the time the average patient has an x-ray examination, the dilatation is extreme. Indeed it is the diagnostic feature, because no other form of stricture—even cancer with which cardiospasm is most likely to be confused—produces such dilatation. This is largely because in the case of cancer the tumor becomes canalized and some food gets through. In cardiospasm the obstruction, while it lasts, is absolute.

Occasionally one may find presumptive x-ray evidence of a cardiospasm upon a film of the chest because of a characteristic paravertebral or columnar density caused by the food retained in the esophagus above a cardiospasm.

As time goes on, if left to itself, the cardiospasm usually gets worse. Compensation fails and the dilatation of the esophagus attains quite bizarre pro-

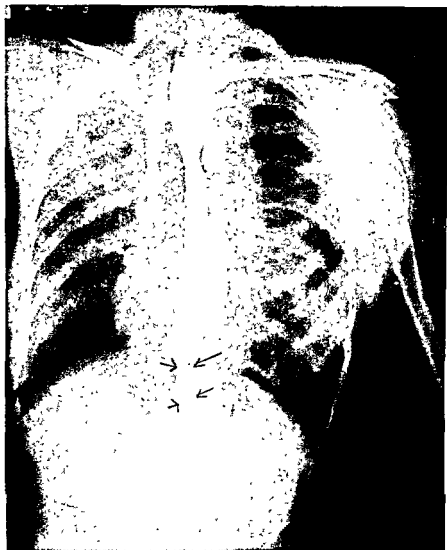


Fig. 111.—Cardiospasm.

portions, becoming possibly tortuous. The configuration has been divided into: (1) fusiform types; (2) flash, pear-shaped, or champagne bottle shaped; and (3) S-shaped types.

5. Varices of the Esophagus.—Wolf, in 1928 (*Fortschr. a. d. Geb. d. Röntgenstrahlen* 37: 890), first demonstrated esophageal varices in a patient

who died and came to autopsy. Syphilis of the liver and spleen were found, and also the confirmation of the presence of the varices. Wolf made several fundamental observations which have been confirmed: the evidence of varices may disappear for a time, only to return in the same location. There may be associated delayed emptying of the esophagus. The varices may be demonstrable



Fig. 112.—Esophageal varices.

roentgenologically before any evidence of cirrhosis of the liver or hepatosplenic disease can be obtained by other methods. The demonstration of esophageal varices may explain cases with the syndrome of internal hemorrhage or obscure secondary anemia. In making the examination a mucilaginous barium mixture is preferable. (Rugar.) The characteristic feature of the picture is the presence

of circumscribed rounded defects in the lower end of the esophagus, protruding into the lumen. In advanced cases the entire esophagus may become involved. The diagnosis should be easy, as the appearance is quite pathognomonic. However, even in some cases in which we are certain, from clinical findings, that esophageal varices are present, it may be impossible to demonstrate them. Widening of the longitudinal mucosal folds is an additional piece of evidence, as is the characteristic that the picture may change under observation when peristaltic waves obliterate a bunch of varices.

6. Peptic Ulcer of the Esophagus.—Jackson (J. A. M. A, 92: 369, 1929) reported that in 4,000 cases of esophageal disease he made the diagnosis of ulcer in 88 instances. The findings of Tiletson on autopsy material in Boston (4,496 autopsies), and the Bellevue Hospital records (22,810 autopsies) are identical to a decimal point—the incidence of peptic ulcer of the esophagus was 0.13 per cent in both series. Peptic ulcer of the esophagus occurs almost always at the lower end just above the cardia. It is undoubtedly associated with regurgitation of acid stomach contents. The short esophagus and thoracic stomach furnish a favorable anatomic ground for the production of these ulcers. The symptoms are dysphagia (100 per cent), pain (84 per cent), hemorrhage (53 per cent), vomiting (54 per cent), and perforation (14 per cent). The pain is located in the epigastrium or beneath the stomach and radiates to the back, between the shoulder blades. A definite hypersensitive area over the ninth dorsal vertebra is suggestive. The pain may occur without swallowing, but is always increased by the act of swallowing. Relief is usually obtained by the ingestion of alkalis. The roentgen ray diagnosis depends on the demonstration of the niche. These are similar in principle to Haudek's niches on the lesser curvature of the stomach. Associated with the niche are spasm and functional stricture. Organic stricture may supervene.

7. Short esophagus—thoracic stomach—is discussed in connection with diaphragmatic hernia.

8. Esophagitis is an extremely rare condition. Syphilis has been described convincingly only about fifty times. Its x-ray appearance is of a rigid-walled esophagus in the upper or middle portion with smooth narrowing merging into normal stricture toward the cardia, with, or more often without, obstruction. (See Wilcox: Am. J. Roentgenol. 31: June, 1934.) Tuberculosis is equally or even more rare. Feldman declares that there are no pathognomonic x-ray signs.

9. Carcinoma of the Gastric Cardia.—Patients with carcinoma of the gastric cardiac portion of the stomach may present as their first symptoms a difficulty or sensation of difficulty in swallowing, with some degree of substernal pain. When such patients are studied by x-ray methods, they should be prepared identically as for gastric examination—abstinence from food for at least twelve hours, Hodges has shown.

10. Displacement and compression of the esophagus is caused by dilated auricle in mitral disease, general cardiac enlargement, aortic aneurysm,

thoracic deformity, mediastinal tumors, pleuropulmonary disease, and pericarditis. The thorough roentgenologist will add the visualization of the esophagus to his ordinary examination of these conditions and help greatly in visualizing them, though the examination has no significance so far as the esophagus itself is concerned. (For full discussion see Brown and MacCarthy: *Radiology* 24: 131, 1935.)

C. The Stomach

The Stomach and Intestines.—During the entire period of my internship in a large Chicago hospital there was no x-ray apparatus available for anything but fracture work. It was the heyday of gastric surgery, and we had plenty of opportunity to check our diagnoses. Indeed the exploratory laparotomy took the place in our routine, of the x-ray examination. As I recall it our diagnostic success was quite high.

Later, when I entered clinical practice, I was shown the work of Haudek and Holzknecht, which, of course, fascinated me. I had obtained a dispensary service and I once collected three cases for the surgical clinic of my colleague, Dr. W. S. Sutton. In all three the diagnosis of carcinoma of the stomach had been made on x-ray evidence when there was no palpable tumor or visible peristalsis or other physical signs to back it up. In all three cases on exploration the carcinoma was found as predicted. I remember my pleasure, standing there in the operating theater, while Dr. Sutton complimented me and said to the class, "This is the most remarkable series of cases of the kind I ever saw brought together at one time." Curiously it did not seem so remarkable to me: I had been used to a large surgical clinic where our diagnoses, made by clinical methods were pretty regularly confirmed. I bring in this personal recollection merely to point out that I have been through the mill. I have lived during a period which enables me to appreciate the importance and improvement in the x-ray examination of the gastrointestinal tract. I also could assess it. I have continued to be interested in it, but now, after thirty years, I have a sense of disappointment in it. The x-ray examination of the gastrointestinal tract does not give us as much as once I hoped and expected it would. As I see a succession of patients of the exact category in which it might be expected to help, I am aware of a curious lack of helpfulness.

Most of the blame for this lies in poor technique in x-ray laboratories. Long ago the issue was debated as to whether more and better information is obtained by fluoroscopy or by plates. The serial plate method is a variation, but it is restricted for economic reasons to a small minority of patients. The roentgenologist generally prefers the fluoroscope and refers to that kind of examination grandiloquently as "physiologic." The clinician, on the other hand, even though he takes time to follow his patient through the fluoroscopic examination, prefers to have a permanent record of the findings. Now obviously this film should be taken with the patient in the upright position, certainly at least with no pressure on the abdomen. And just this the average x-ray laboratory, in or out of the hospital, fails to do. The patient is instructed to lie face

down on the plate and the x-ray tube flashes from above. This position flattens out all the landmarks of the stomach and intestine and obliterates the filling defects of ulcer and many other lesions.

As to the fluoroscopic examination alone, a "physiologic" examination should theoretically be of great value to the clinician, but it is really singularly barren. I have diligently searched the literature to find statistics on how successful the fluoroscopic method alone is in the diagnosis of such conditions as duodenal ulcer and gastric ulcer, but there is a reticence which almost amounts to a conspiracy. Feldman states of gastric ulcer, "The percentage of radiologic diagnostic accuracy is exceedingly high and varies between 50 and 96.6 per cent as shown in Table 21," but Table 21 lists the reliability in cases of known ulcer. There is no mention made of negative failures: cases in which ulcer was present and no x-ray evidence of such presence indicated. Nor have we any statistics on a consecutive series of miscellaneous cases with indication of how often fluoroscopic examination alone demonstrated an ulcer.

Good roentgen technique of the gastrointestinal diagnostic examination would, in my opinion, be defined as a fluoroscopic examination with the operator prepared, as soon as the pathologic condition is visualized, to make immediately a film or series of films with the patient in the upright position (certainly always for stomach cases) or lying down without pressure on the abdomen (in intestinal cases). Such technique may be routinely carried out in a few enlightened centers, but in my experience again it is far from generally observed in this country and the clinician must be the one to insist on it if any weight is to be placed on the x-ray examination. Certainly it is the first thing the clinician should know about the films he is examining when a gastrointestinal case is under consideration.

In general, in my experience the x-ray may be assessed thus in the diagnosis of diseases of the stomach and intestines:

1. Of great value for either positive or negative evidence:

Cancer of the stomach.

Linitis plastica.

Benzoars and foreign bodies

Congenital hypertrophic pyloric stenosis. (With some reservation about the advisability of the examination at all.)

The flat abdominal film (without barium) in suspected intestinal obstruction. (Patient vertical, if possible.)

Ulcerative colitis.

Mucous colitis.

Enterolith.

Hirschsprung's disease.

Idiopathic dilatation of the colon in adults.

Cancer of the colon.

2. Of moderate value when positive:

Gastric ulcer.
 Duodenal ulcer.
 The postoperative stomach.
 Regional ileitis.
 Tuberculosis of the intestines.
 Tumors of the small intestine.

3. Of some value as evidence of the physiology involved:

Constipation.

4. Of slight or no value if x-ray evidence is negative:

Gastric ulcer.
 Duodenal ulcer.

5. Information accurate but of little or no clinical value:

Position and tonus of stomach and intestines.

What symptoms should lead a practitioner to demand an x-ray examination? Kirklin stated this excellently at the 1942 Kansas City Annual Fall Clinical Conference as follows:

1. Hemorrhage by emesis (bright red) or in the stool (dark red or black).
2. Anemia of sudden onset.
3. Loss of weight occurring suddenly.
4. Abdominal or epigastric pain with sudden onset.
5. Palpable tumor suspected in gastrointestinal tract.
 (The foregoing symptoms apply particularly to gastric cancer.)
6. A dyspepsia appearing after the age of forty. (Gastric ulcer or cancer suspected.)
7. Hunger pain about two hours after meals in the nervous, high-strung individual which is relieved by food. (Duodenal ulcer or irritation suspected.)
8. Gas and fullness after meals in the stout individual, with pale stools. (Gall bladder disease, with or without stones suspected.)
9. Pain immediately after meals, relieved by alkali or soda. (Gastric ulcer or gastritis suspected.)
10. Irregular bowel habits and explosive stools appearing after forty. (Cancer of distal colon or rectum suspected.)

METHODS OF EXAMINING THE STOMACH BY X-RAYS

What appears above will indicate sufficiently my own convictions about the routine procedure for x-ray examination of the stomach. The patient abstains from food and drink the night before and at breakfast, except for minimal liquids, and presents himself in the morning. The fluoroscopic examination of the esophagus and the lungs will be carried out along with the barium meal. Anteroposterior and oblique fluoroscopy is applied and spot or plain films are taken with the patient in the vertical position. Such information regarding the small intestines as is available upon follow-up examinations at the five- or six-hour interval may demand more extended studies of the small

bowel, so that neoplasms of the jejunum or the ileum or terminal ileitis may be recognized. A particular symptom may suggest different intervals of x-ray study after a barium meal; a variation of the type and consistency of the opaque meal may be useful; if the site of a hemorrhage is sought, the suspected site might be re-examined if the first examination is negative. Compression or spot films of suspected lesions at the duodenum, gastric cardia, small and large bowel amplify fluoroscopy or routine films.

WHAT TO OBSERVE AND RECORD IN STOMACH ROENTGENOGRAMS

The size, capacity, position, contour of the curvatures, flexibility, mobility, peristalsis, tone, emptying time, and filling defects.

The stomach in the upright position shows most of the barium filling it from the pylorus up, with a fluid level toward the cardia and a large air space—air bubble or magenblase above.

The tone of the stomach can be judged by the way in which the meal is held in the upright position.

The form of the stomach varies with different individuals. It is dependent largely on whether the stomach lies high under the costal arch, is small in size, and points the pylorus straight across on a level with the greater curvature—the steer-horn stomach of Holz knecht. The other common form is a stomach which hangs, as it were, from the esophagus with the pylorus far above the greater curvature, but itself lower than the left costal margin—the fishhook type of stomach of Rieder. These descriptions were made in 1904 and 1912 by Rieder and Holz knecht and many classifications of stomach form have been made since then, all using these descriptions as a basis. Probably the best of all is that of R. Walter Mills, who correlated body form with anatomic position, shape, and tonus. The heavy-set individual, with a wide costal angle, is inclined to have a high, small, steer-horn stomach. The tall, slender individual with long chest and narrow costal angle—the visceroptotic type—is inclined to have a low hanging, fishhook type of stomach. Mills named four types of stomach as: hypertonic (5 per cent), orthotonic (48 per cent), hypotonic (35 per cent), and atonic (12 per cent). Undoubtedly tonus has as much to do with these as actual anatomy. Holz knecht recognized this apparently, since he called his paper "Röntgendiagnose der Magenatonie"; and Schlesinger described four forms of stomach on the basis of tone exactly corresponding to Mills.

Peristaltic waves move through the stomach constantly and can be seen under the fluoroscope. The emptying rate of the stomach is a valuable fact to record. It varies from three to five hours. Barium begins to leave the stomach immediately after ingestion and continues regularly. There is considerable variation in emptying time, depending on the character of the meal. A watery meal should leave the stomach in an hour. A carbohydrate meal leaves in four hours, a protein meal in five to six hours, and a pure fat meal in nine hours. For a mixed meal the general average of six hours is a good standard. Briggs found the following in routine consecutive cases:

Cases per cent:	0	1	6	9	44	32	8	0	
Hours:	2	2½	3	3½	4	4½	5	5½	-8

The emptying rate of the stomach, therefore, does not become of clinical significance until after eight hours at the least, if we are observing delayed emptying and before two hours if we are observing rapid emptying.

The mental condition of the patient during the examination may alter the emptying rate of the stomach. Headache will slow it. Emotional upsets and particularly anger slow the emptying rate and may alter the pattern of the small bowel segments. Attempts should be made to seek the cooperation of the patient rather than proceed with a mere routine or unsympathetic examination.

The flexible gastroscope, introduced into this country by Schindler, has been a most important contribution to gastric diagnosis. It may provide early differentiation between carcinoma and peptic ulcer. It can show gastritic conditions, both acute and chronic, which are not recognized on x-ray examination. It can supplement the x-ray studies as regards the questionable finding of many conditions. Small gastric erosions may be picked out gastroscopically by the careful examiner. The gastroscope has a great future. (Geyman.)

ROENTGENOLOGIC DIAGNOSIS OF DISEASES OF THE STOMACH

Congenital Hypertrophic Stenosis of the Pylorus.—There is some difference of opinion as to whether the x-ray should be used at all in the diagnosis of hypertrophic stenosis of the pylorus. Dr. Edward J. Donovan, of the Babies Hospital, New York, says that x-ray examination is entirely unnecessary in diagnosing cases suspected of being congenital pyloric stenosis. The tumor, he states, is palpable in 100 per cent of cases, and it is a rule of the hospital that no patient be operated upon unless a tumor is palpable. In some instances it may be necessary to empty the stomach with a tube before the tumor can be palpated, but this is in only 2 per cent of cases. Babies who have had a barium meal and x-ray examination suffer more postoperative discomfort if all the medium has not been examined before operation. On the contrary, Dr. Robert A. Arens, of Chicago, says that the x-ray examination is always necessary because so much difference of opinion arises as to whether a tumor is present or not: even the most experienced consultants in his experience disagree ("Modern Medicine," May, 1941).

The x-ray examination is, at any rate, an extremely reliable method of diagnosis. The x-ray findings of congenital pyloric stenosis are in the order of their importance:

1. Retention of gastric contents. The amount of obstruction, of course, varies. Tarr (Arch. Ped. 36: 154, 1919) recommends the making of three films, first immediately after the administration of barium, the second at the end of 2½ hours, the third at the end of 3½ hours. In complete stenosis practically all of the opaque meal will be in the stomach, in partial obstruction some of the meal will have gone through the pylorus. Strauss (S. Clin. Chicago, 1920) states that when 80 per cent of the meal is retained in the stomach at the end of four hours the case is unsuited for medical treatment.

2. Obstruction at the pylorus is noted by fluoroscopy. A tumor which has not been felt by ordinary clinical methods can be under the fluoroscope by directing the palpating fingers with the aid of seeing where the pyloric stoppage is.

3. The shape of the stomach is usually quite characteristic. A round ball racked with hypermotility going up against the pylorus. The pylorus in these cases is often a small almost cartilaginous ring: in extreme cases emptying is practically impossible.



Fig. 113.—Hypertrophic pyloric stenosis.

4. Peristalsis, tone, dilatation of the stomach depends upon the degree of obstruction and the time elapsed before the film is made. As the child gets weaker, the peristalsis and tone decline.

Every grade of obstruction occurs. A condition of pyloric spasm in the newborn has been described in which no organic obstruction exists at all. About

35 per cent of cases have so little obstruction they can be treated medically.

Gastric Ulcer.—General types of gastric ulcer are distinguished:

1. Shallow mucosal erosions. These may occur in any toxic condition, are multiple, and heal readily when the toxemia is over. They have no clinical significance.



Fig. 114.—Gastric ulcer with niche.

2. Penetrating callous ulcer with deep crater.
3. Perforating ulcer with or without the production of an accessory pocket.
4. Malignant ulcer.
5. Ulcerating benign tumor. Only the second, third, and fourth types are considered here.

Haudek's original points for the roentgen diagnosis of gastric ulcer, first published in 1910 (München. Med. Wehnschr. 57: 1587, July, 1910), have not been superseded or materially added to. They were:

1. Diverticulum-like projection of the stomach generally on the lesser curvature—the *niche*.

2. A gas bubble in the niche itself when the patient remains erect.

3. A residue of bismuth in it, for a protracted period

4. The inability to influence this area by palpation or massage.

The "*niche*" is naturally the positive sign of gastric ulcer because it is the roentgenologic deformity which results from ulcer. But obviously for a *niche* as described by Haudek to be present a special type of gastric ulcer must be present. It must be a penetrating callous or perforating ulcer, it must be on the lesser curvature, just above the incisura angularis. Gastric ulcer appears on the lesser curvature, above the incisura angularis in about 80 per cent of cases (Newcomb's statistics collected in 1933 give 83 per cent. Welch's autopsy statistics show that in 793 cases, 288 were on the lesser curvature, 235 on the posterior wall, 69 on the anterior wall, 95 at the pylorus, 50 at the cardia, 29 at the fundus, and 27 on the greater curvature). Gastric ulcer is characteristically more likely to be callous and penetrating (therefore less likely to be healing) than duodenal ulcer. Rivers and Bowers (Northwest Med., 1934) found that 50 per cent of gastric ulcers were penetrating in type. Pathologic conditions would therefore favor the presumption that a large percentage of gastric ulcers would show a *niche* on roentgenologic demonstration.

The difficulty lies, as I intimated in the beginning, in technique. Part of this is intrinsic in the pathology. Niches in the exact center of the *magenstrasse* (on the skyline or horizon of the lesser curvature—Aschoff's *magenstrasse*—the road the food and gastric contents take to rush to the pylorus, on which his theory of the formation of peptic ulcer is based) are easy to demonstrate, provided the patient is photographed in the upright position. In a third of Welch's cases, however, the *niche* was on the posterior wall, and the demonstration of those niches required special and patient attention in getting the patient in the right position. The same applies to the one per cent of cases in which the *niche* is on the anterior wall. (I recognize the value of Berg's procedure in this connection: he pointed out that the *niche* is often obliterated by a large barium meal and suggested compression with a small meal over the suspected area; this often demonstrates what he calls a "relief *niche*.") So, even with the *niche* present and in the favored site, we may not expect positive clinical demonstration—that is, under the ordinary conditions of clinical practice in this country—in more than 50 per cent of actual ulcers present.

Among practicing radiologists the *niche* incidence of gastric ulcer is 90 per cent or better. Remember, we are discussing *niche* formation. *Niche* demonstration in duodenal ulcer is considerably less frequent than in gastric ulcer for two reasons: First, the physical character of the ulcer is different in the duodenal bulb. In the acute stage of a fresh ulcer the crater is almost invariably demonstrable after careful search, because the barium is retained in the crater pocket.

In most gastric ulcers the crater is deeper and remains demonstrable until the ulcer is almost healed. In most chronic duodenal ulcers the crater is small, shallow, and smooth, and no barium fleck remains, even though a most painstaking technique is used. Second, the reason that niche demonstration in duodenal ulcer is less frequent than that in gastric ulcer is that compression technique is necessary. Compression technique is not harmful for, if properly used, the

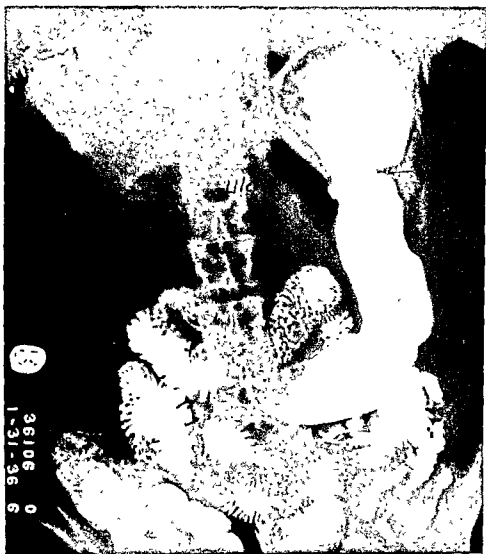


Fig. 115.—Ulcer of stomach. Note incisura and niche.

necessary compression is slight. If, however, x-ray studies seem necessary during or after hemorrhage, it is not wise to palpate the barium-filled stomach, and the patient should always be prone. The bleeding lesion, especially in the bulbus duodenum, is difficult to demonstrate by x-ray. In spite of the difficulties in demonstrating niche formation, the diagnosis of ulcer of the duodenum may be as high as 97 per cent in some hands. There is no question but that more small

gastric ulcers than duodenal ulcers are overlooked. The roentgen study of the duodenal bulb is more accurate than that of the stomach. Diagnosis of gastric ulcer by roentgenogram is considerably less accurate than that of duodenal ulcer—at least 10 per cent less. (Geyman.)

Ulcer at the pylorus on the gastric side may be demonstrated as a niche. However, obstruction with delayed emptying rate occurs so often in this site of ulcer that these signs are more reliable. Elongation and rigidity of the pyloric canal is another sign.

Ulcer on the greater curvature is so likely to be malignant that it will be discussed below under that heading.

Niche, then, being the one acknowledged "pathognomonic" roentgenologic sign of gastric ulcer, other confirmatory signs must be considered. Incisura, or spasm, orientation on the greater curvature exactly opposite the site of ulcer on the lesser curvature, is the most frequent of these. It occurs when the muscularis coat of the stomach has been deeply penetrated by the ulcer, resulting in persistent contraction of the musculature. Continued contraction may, of course, result in cicatricial contraction of the same kind, or *hourglass stomach*: it is more than often the sign of an old healed ulcer. The crossbar of Frankel is another valuable sign: in such cases no niche formation occurs, but there is a small straight area on the lesser curvature which remains constant and does not share in peristaltic activity. Obstruction and retention have already been referred to the 55 per cent of Carman's 215 cases that had a retention at six hours.

Malignant Gastric Ulcer.—When what appears to be a benign ulcer filling defect appears on the greater curvature and/or is 2 cm. or more in diameter, malignancy may strongly be suspected. Beckman states that in his experience, with one possible exception, ulcers of the greater curvature have invariably been malignant. As the average size of ulcers is 5 to 55 mm., an ulcer with a diameter of 2 cm. may be considered very large, although many authorities prefer to put the danger figure at 2.5 cm. Pyloric ulcerations are also suspected.

The significance of such standards is obvious. Palliation by medical treatment in such cases is out of the question. Whether or not benign ulcers "develop" malignancy is a purely theoretical question: the figures collected by various observers indicate that from 3.75 to 10 per cent, depending on the observer, become malignant. What is really meant, I believe, is that many ulcers are malignant. But whether they develop malignancy or are malignant from the beginning is of no practical consequence, for when the above signs are present, malignancy may be assumed. Other clinical signs—ulcer symptoms of short duration, in a middle-aged individual, with achylia, and poor response to alkalis—are confirmatory, but the roentgen demonstration is the final criterion. Some do not have symptoms of short duration, but may have complained for five or ten years: in such cases the question of ulcer developing into malignancy arises with some reason. But the character of the cell of these cancers is peculiar.

These scirrhus ulcers have a curious postoperative history. Even with an apparently very complete and early removal, metastasis seems inevitable. Five

years is the classical period for the onset of the secondary symptoms—vertebral or hepatic metastasis usually—sometimes generalized peritoneal (signet ring type) implants. The cells of which they are composed, always potentially malignant, may lie dormant for years either at the original site or at the metastatic site. I knew one patient who developed metastasis ten years after the removal of the malignant ulcer. They are indeed a clinical entity.



Fig. 116.—Gastric ulcer large enough to be considered malignant.

Multiple ulcers of the chronic callous type are of the utmost rarity. Fenwick put the figure at 13 per cent of all gastric ulcers, but this is obviously too high. Acute ulcers, or erosions, are nearly always multiple.

Gastric and duodenal ulcer may coexist. The exact incidence varies so greatly in different reports that it is difficult to determine the exact figures. The highest figure reported was that of Judd and Proctor, and it was based on operative findings in 1475 cases; 247, or 16.7 per cent, were found to have gastric and duodenal ulcers. Emery and Monroe (*Arch. Int. Med.* 55: 271, 1935) found an incidence of only 1.8 per cent. Judd and Proctor's figures probably include saddle ulcer.

Perforation.—The roentgenologist employs a different connotation for the word "perforation" in connection with ulcer from that of the surgeon or clinician. When real perforation occurs, x-ray diagnosis has no place. What the roentgenologist means by perforating ulcer is what the clinician calls "leaking ulcer"—impending perforation. The x-ray signs are (1) accessory pocket, (2) air in the peritoneal cavity, (3) depth of crater, size of air bubble and fixation to other structures.

Intraperitoneal Air.—A flat film of the abdomen with the patient prone is useless. The erect position is preferable to obtain a level of air under the diaphragm, usually the right side. Information may be obtained from a film made with the patient resting upon the left side and from the anteroposterior projection. Probably only two-thirds of ruptured ulcers show free air under the diaphragm. The patient's condition must not be jeopardized in order to obtain this x-ray information.

Hemorrhage is a relative term. I have read with some amusement the discussions of hemorrhage by authors of textbooks on gastrointestinal roentgenology, and conclude that as for rushing in, the roentgenologist had better prepare to play the role of angels.

Healing of Gastric Ulcer.—The x-ray examination may offer confirmatory (to the clinical evidence) signs of the healing of a gastric ulcer. These signs are particularly comforting to the clinician because they are anatomic, while the clinical signs are symptomatic. During the process of healing the niche, or crater, becomes shallow and V-shaped, and then flattens out. A warning is held out that there may be some pitfalls involved in the conclusion that healing is occurring. According to Forasell, rapid healing may seem to be taking place when nothing but a swelling of the folds of mucous membrane surrounding the active ulcer has actually occurred. This would seem to be the edema that Dr. Sippy explained in connection with both gastric and duodenal ulcers.

Postoperative study of the stomach when either gastric or duodenal ulcer has been present is of value. In the case of gastro-enterostomy bad position, too small or too large a stoma may be observed. Bad position means too high, so high that as the stomach hangs in the erect position the stoma is above the level of outlet and even kinks the jejunum. The stoma may, on the contrary, be so well placed and so large that all the contents of the stomach rush out.

The postoperative jejunal ulcer can be observed roentgenologically as a niche. It may have an incisura opposite. There may also be a marked retraction of the greater curvature of the stomach at the site of the anastomosis. All three of these findings are difficult, and all three may be absent. This is most difficult clinical estimation to substantiate by x-ray studies.

Gastrocolic Fistula.—A barium enema study should always complete the x-ray study of an enterostomized patient, as only by this procedure is a gastrocolic fistulous tract consistently revealed. The gastrointestinal tract must be cleared of any opaque residues and the stomach must be empty ahead of such an opaque enema.

CARCINOMA OF THE STOMACH

Ninety per cent of gastric carcinoma either project into the lumen of the stomach in a position where a barium meal will outline the filling defect, or are at the pylorus causing obstruction (at the pylorus they may cause both a filling defect and obstruction) or produce an unduration in the gastric wall which is demonstrable by x-ray.

Types of Carcinoma.—Gastric carcinomata are classified as follows: (1) medullary, fungating, proliferating or vegetating, 64 per cent; (2) scirrhus, either infiltrating, ulcerating, or leather bottle variety, 32 per cent; (3) mucoid, related to scirrhus, but with masses of gelatinous material abounding.

The polypoid type occurs on the pars media, either greater or lesser curvature, the scirrhus at the pylorus with sufficient regularity to make it a rule. Five per cent of carcinoma arises on the posterior wall of the stomach. About 8 to 10 per cent arises at the cardia, cardio-esophageal juncture, or fundus.

X-ray Signs of Carcinoma at the Cardio-esophageal Junction (after Feldman).—

1. Infiltration of the lower end of the esophagus, preventing passage of opaque media.
2. Dilatation of the lower end of the esophagus in advanced cases of obstruction.
3. Abnormal retardation of the barium in the lower end of the esophagus in advanced cases of carcinoma of the cardia.
4. Esophageal antiperistalsis.
5. Disturbance of the mechanism of the cardiac sphincter, resulting in a reflex of opaque media into the esophagus.

X-ray Signs of Carcinoma of the Cardia.—

1. Filling defect or irregularity of the passage of food into the stomach from the esophagus, observed under the fluoroscope.
2. Absence or irregularity of the *magenblase*.
3. Shrinkage of the stomach and possibly displacement.

X-ray Signs of Carcinoma of the Body of the Stomach.—

1. Filling defect—irregular.
2. Diminution in size of the stomach.
3. Altered peristalsis and motility.
4. Displacement of the stomach.

X-ray Signs of Carcinoma at the Pylorus.—

1. Filling defect.
2. In absence of filling defect obstruction, retention, dilatation of stomach.
3. Elongated pylorus, stiff pylorus, straight line effect.

Differential Diagnosis Between Carcinoma and Ulcer of the Stomach.—

1. Malignant ulcer (see above) usually on greater curvature, more than 2 cm. in diameter.
2. Predilection of carcinoma for the pylorus, of ulcer for pars media lesser curvature.



Fig. 117.—Carcinoma of stomach.

3. Lymphomatous tumors of the stomach may provide large filling defects and produce hemorrhage and fail to present a palpable mass of density. When suspected in a patient with an extensive filling defect and no paralleling cachexia and no evidence of syphilis, a therapeutic test of high voltage x-ray therapy up to 400 r. in four days is useful. These growths are quite radiosensitive. The

recession of the filling defect is not complete, but sufficient to warrant prolonging the x-ray therapy. Such a therapeutic test may obviate an exploratory laparotomy.

Linitis Plastica (Leather Bottle Stomach).—This rare condition consists of a stomach with a large part of its walls rigid and inflexible due to a diffuse infiltration. There has in the past been some difference of opinion as to whether it is due to syphilis or carcinoma. Ewing states that it is carcinoma of the scirrhus or fibrocarcinoma type. Most pathologists agree. There is, however, an evidently benign type, some cases of which have improved on treatment with iodide of potash.

The x-ray appearance in a typical case is unmistakable. The stomach pouch is small, with diminution, or absence, of peristaltic activity, a tubular type lumen, often including the cardia and pylorus, with wide open pylorus. Sometimes there are filling defects in the course of the smooth infiltration.

Foreign bodies in the stomach are readily visualized if of metal. Bezoars—trichobezoars or hair balls and phytobezoars or food balls—are not common. Hair balls may not be detected for years: the habit of eating hairs has its beginning in early childhood. Butterworth states that without exception patients in whom hair balls occur are mentally sound. On the x-ray plate when barium has been given, the balls are usually readily detected as spongy or stringy looking masses that change position readily. Small bezoars float on top of the barium near the magenblase. Food bezoars, such as the persimmon bezoars, are caused by any food that cannot be digested and forms a mass. The x-ray picture is of barium filling in and around a mass, looking like a kind of ghost of a stomach.

Syphilis of the Stomach.—Jonathan Hutchinson, in 1887, said he knew of no museum specimens or published reports of syphilis of the stomach. The subject is certainly in the debatable field. Eusterman, however, described ninety-three cases. (Gastric Syphilis, J. A. M. A. 96: 173, Jan., 1931.) In the advanced stage the stomach was similar to linitis plastica. Some had hourglass contraction. Beckman states, "There are no changes in the radiographic appearance of the stomach which can be considered as peculiar to syphilitic infection and which are certainly differentiable from the various types of deformity produced by malignant infiltration."

It is possible for syphilis to produce filling defects of the stomach that are identical with scirrhus carcinoma and linitis plastica. Such syphilitic gummata are usually larger than consistent with the physical appearance of a patient who has actual carcinoma of the stomach. Therefore, it is almost axiomatic that when the physical appearance of the patient belies the roentgen diagnosis of gastric cancer, syphilis should be suspected and a competent therapeutic test made before submitting the patient to surgery.

Tuberculosis of the Stomach.—It is a regular procedure to recover and stain tubercle bacilli from gastric washings even when none can be found in the sputum, but the stomach wall, or mucosa, is seldom invaded. When it is, it

takes the form usually of multiple ulcers. There is, however, according to Beckman, no criterion upon which the roentgenologic diagnosis of tuberculosis can be based.

Lymphoma of the Stomach.—This is a very important subject and one that is quite generally neglected. It is discussed in the section on symptomatology. The x-ray diagnosis is made on the basis of (1) filling defect with smooth margins, localized or annular if it involves the pylorus; (2) partial or complete stenosis; (3) changes in peristalsis—sluggish or irregular; (4) rigid appearance of the gastric wall; (5) involvement of the muscularis and submucosa. Relief pictures show the mucosal rugae thrown into thick folds and not completely effaced as seen in carcinoma. The x-ray appearance will naturally depend upon the location and size and diffuseness or localized nature of the tumor. Differential diagnosis lies between gastric ulcer and carcinoma and is admittedly puzzling.

Diverticulum of the stomach is rare. It may be congenital or acquired; it may have a predilection for the cardia or may occur at the pylorus and are usually readily recognized by the x-ray appearance.

Benign gastric tumors are rare. They include polyps, myoma, lipoma, fibroma, angioma, adenoma, and cysts, and present an x-ray appearance difficult to differentiate from the commoner tumors. *Polyposis* may be of a single large pedunculated polyp, usually near the pylorus, which may become carcinomatous, or polyadenoma of the type of Brunner's glands may develop, or multiple polyposis, scattered over a wide area of the surface of the stomach. The x-ray picture—a dark area in the barium map—is sometimes quite characteristic, sometimes confusing. *Extrinsic masses produce pressure defects* on the stomach and other parts of the gastrointestinal canal. A tumor of sufficient size can grow in proximity to the stomach or the colon and, by pressing on its external walls, produce a deformity. The stomach is the commonest site for this because the stomach is relatively fixed and large enough to show defects readily. The small intestines are not so frequently involved, but the colon all the way to the sigmoid may be.

The small bowel is becoming increasingly apparent by x-ray studies. Not only are more cases of neoplasm found by x-ray before the obstructive stage, but nutritional deficiencies produce characteristic alterations in the motility and the segmentation of the barium meal. Snell and Camp (Arch. Int. Med 53: 615, April, 1934) first described changes in the small bowel structure with chronic steatorrhea. Golden (J. A. M. A. 117: 913-917, Sept. 13, 1941) describes changes in the mucosa which occur in deficiency states.

Regional ileitis must be suspected in chronic gastrointestinal disease with negative opaque meal studies of the stomach and intestines. Small bowel diseases are not, as a rule, revealed by the routine x-ray series. They must be looked for specifically by timed and repeated x-ray studies.

The large bowel, with the exception of the rectum, is most helpfully studied by x-ray methods. Where some degree of obstruction is suspected the barium enema should be the first phase of the x-ray examination. Otherwise, an ob-

structing carcinoma of the sigmoid might dam back a heavy column of barium and embarrass the surgical procedure necessary. The contrast enema, as carried out by Weber, may reveal polypoid lesions invisible to the conventional heavy; opaque barium enema.

D. The Intestines

Ulcer of the Duodenum.—The duodenum is a fixed retroperitoneal portion of the gut without mesentery. In the x-ray picture the first part of the duodenum appears as a smooth triangle or liberty cap-shaped structure called the duodenal bulb. It has normally a quite characteristic appearance. This part of the duodenum, so far as its mucosa and musculature are concerned, is much more like the stomach than the small intestine. The gastric rugae run out into the bulb. Only lower down does the intestine acquire the feathery appearance due to the annular arrangement of the rugae—the valvulae conniventes.

The apex of the duodenal cap is held by the duodenohepatic ligament. Four types of duodenum are distinguished by roentgen appearance:

1. With a fishhook stomach, a cylindrical, pear-, or pyramid-shaped bulb. (Hyposthenic, gastrocoloptotic type.)

2. A shorter cap directed to the right, with moderately hypertonic stomach. (Sthenic or median normal type.)

3. With the steer-horn stomach, the cap is usually visualized with difficulty in the erect position; it is round and small. In the prone position it often lies behind the pyloric portion of the stomach. (Hypersthenic type.) Examine by x-rays preferably in erect position and oblique projection.

4. With the atonic, or hypotonic, stomach, the cap is more cylindric and elongated.

The cap in the average person runs from inferior anteriorly to superior posteriorly. Thus, with the patient in the anterior position it is seen foreshortened. In order to examine it more clearly, the patient must be examined in the right oblique position.

The only common intrinsic lesion of the duodenum is ulcer. The causes of duodenal ulceration are probably much the same as those of gastric ulcer, but duodenal ulcer occurs approximately ten times as often as gastric ulcer. In a consecutive series of 6,669 patients the diagnosis made from x-ray pictures was 4,673 duodenal ulcers and 1,986 gastric ulcers. In 90 per cent of cases duodenal ulcer is single, in about 8 per cent of cases double, and in 2 per cent multiple (the last the acute toxic variety). Its position is usually juxtopyloric (close to the pylorus). Fifty-four out of sixty cases observed by Akerlund were on the lesser curvature.

Pathologically duodenal ulcer may be mucosal, penetrating, indurated (chronic), and perforating.

The reliability of x-ray diagnosis of duodenal ulcer is, according to the roentgenologists, 95 per cent.

The x-ray signs of duodenal ulcer, depending on pathologic variety, are:

1. Niche-filling defect.
2. Deformity of the bulb—loss of convexity, flattening, shortening, narrowing, contraction, diverticulae, sacculations, accessory pocket, annular ridge, star-shaped, or sun-ray deformity.
3. Spasm of the bulb. Incisura due to localized unilateral spasm, or puckering around the ulcer.
4. Adhesions—fixation of the bulb.
5. Stenosis.
6. Hyperperistalsis of the stomach.
7. Dilatation and hypoperistalsis of the stomach.

In evaluating these signs I have the same reservations which I expressed under the heading of gastric ulcer, namely, that the success of the examination depends very largely upon the technique employed. The reports of the percentage of successful diagnoses as given by various roentgenologists is a credit to their own skill, but in my experience does not represent the value of the x-ray examination in the mine-run of clinical contacts.

Little need be added in the way of description to the bare enumeration of the signs as given above.

To demonstrate the niche if it be elsewhere than exactly on the profile of the bulb, manipulation by the examiner's hand is necessary, with the patient in front of the fluoroscope. The niche of duodenal ulcer is not like the niche of gastric ulcer very often. It is, indeed, little more than a flat, round, or oval plaque on the bulb margin. And, while it is very easy to write down "niche" and "deformity" and describe them in actual practice, what might be a niche or deformity may leave everyone in a great deal of doubt.

Niche evidence is highly desirable, however, because when it is obtained one has a better basis for comparison with future examinations as healing occurs. (See niche discussion page 754.) (See Geyman: *Am. J. Roentgenol.* 28: 211-221, Aug., 1932.)

It hardly seems necessary to go into the indirect signs in detail. Hyperperistalsis of the stomach naturally occurs when the duodenitis accompanying ulcer is acute and when there is some obstruction, due either to spasm or to edema, at the pylorus. Rapid emptying of the stomach may occur. Hypersecretion may be seen as a layer of fluid on top of the barium, less dense. Gastric retention occurs when compensation has failed.

We have been discussing, by assumption, the chronic type of duodenal ulcer. It is claimed by the roentgenologists that even more important is the early diagnosis, or diagnosis of acute duodenal ulcer. Without prejudice I present these signs:

1. An irritable and spastic duodenal bulb which has a tendency to stay empty.
2. Abnormal fragmentation of the contrast medium in the duodenal bulb. This is a constant finding.
3. The ability of the bulb to fill and become regular under pressure with the examining hand.

4. Temporary spasm of the pyloric antrum, the antrum being regular in outline.

5. Puddling, or overflowing, in the second part of the duodenum.

(See Jenkinson: J. A. M. A. 91: 1716, 1928.)

On the whole, I think in the back of my mind is the rule that if the x-ray findings agree with the clinical recital as given by the patient (and remember that this is so monotonous that Moynihan said, in the unforgettable line, "It sounds as if they were trying to recollect the symptomatology as described in a textbook"), then the x-ray is of confirmatory value. If the x-ray signs are at variance with this history, they should be regarded with skepticism, and the wider the variation, the more profound should be the skepticism.

In differential diagnosis the most important item is a cholecystitis which has caused adhesions between the gall bladder and the duodenum. This may produce symptoms indistinguishable from those of duodenal ulcer, and here the x-ray examination can be of great value, largely through the employment of cholecystography.

Duodenal diverticula and duodenal carcinoma occur, but are so rare as to be negligible clinically. Duodenal diverticulum occurs in less than 2 per cent of autopsies and is clinically silent in most instances. Duodenal carcinoma occurs in 0.03 per cent of autopsies.

The Acute Abdomen.—Ruptures of the hollow viscera, free fluid in the peritoneal cavity, localized abscesses, all types of obstruction and strangulation, acute obstructions of the colon down to the sigmoid are presented optimistically and sometimes dangerously for flat film studies. Rarely is the use of barium by mouth or enema justified. Fluid and air levels demand films in the erect or recumbent side positions. In competent and experienced hands interpretations of clinical value are sometimes obtained. Where the x-ray examination is negative, it should be disregarded, and the clinical and physical examinations of the patient pursued with diligence.

The small intestines are not easy to examine roentgenologically. The coils overlie each other, are in quite constant motion, and empty very rapidly—all of which cause difficulties. The jejunum is different in appearance from the ileum—the rugae are transverse and break the barium up into narrow superimposed plaques or even finer fragments. The ileum presents a smoother and more solid outline. The head of the barium meal should be in the terminal ileum hours after ingestion. After the stomach is empty, the intestines are very soon empty also. Movements of the small intestine are peristaltic, segmentary, and pendular.

Meckel's diverticulum persists in about 2 per cent of all human bodies after fetal life. It varies in length; the average is 5 cm., but it is sometimes 30 or more cm. long. It may lie free, or be attached to the abdominal wall. The attachment may be simply a solid cord, the remains of the vitelline duct. It arises from the ileum about 2 to 4 feet from the ileocecal valve (1 to 2 feet in the newborn): It may be the seat of acute inflammation, perforation, invagination into the ileum or the cause of intestinal obstruction by the rotation of the intestines around the abdominal attachment.

Meckel's diverticulum can sometimes be detected on the x-ray plate, but such visualization is difficult. Inflammation is an even more difficult field for x-ray interpretation. When obstruction occurs, the signs will be dilatation in the upper ileum and jejunum. Meckel's diverticulum must always be remembered when such a picture presents. That is its only claim to importance in the x-ray field.

Tumors of the small intestine are of every variety. Clinically they may range from complete silence to acute intestinal obstruction. Small bowel tumor may be detected by x-ray when suspected by the clinician. It should be suspected in any case of unexplained hemorrhage, where malignancy remains concealed. The x-ray findings consist of an incomplete or complete obstruction in the usual continuous progress of barium through the small gut. The small tumor mass provides a negative shadow amidst the bizarre distribution of the barium meal. Such defects in motility and pattern must remain almost constant in a repeated examination.

Regional Ileitis.—*This disease has only recently become sharply focused on the clinical vision. Such examples as formerly were seen at autopsy were probably dismissed as tuberculous enteritis. Dalziel (Brit. M. J. 2: 1068-1070, Oct. 25, 1913) described a case very accurately, and Moek (Surg., Gynec. & Obst. 52: 672, 1931) described ten cases, but it was not until Crohn, Ginzburg and Oppenheimer (J. A. M. A. 99: 1323, 1932) invoked the magic power of a name and christened it "regional ileitis" that it became familiar.*

Regional ileitis is a nonspecific (or at least the specific organism is as yet not isolated) granuloma affecting the terminal ileum. It begins as an acute inflammation, progressing to ulceration, marked induration with fistulae to the external abdominal wall, or as perirectal abscesses with fistulae, or to intestinal obstruction. The disease begins at the cecum and progresses backward along the ileum until 6, 8, or 12 inches are involved, and then it invades the intestine in skip areas with intervening portions of normal intestine. Enlarged soft mesenteric glands are seen in the drainage area of the involved regions. It is a disease of young adult life, the exact average of a long series of cases being twenty-seven and a half years. But it may occur at any age.

The x-ray picture is perhaps not the final court of judgment in diagnosis of the condition, but it is usually eventually called in to confirm the clinical signs. Chronic regional ileitis may be suspected when there is a long history, with periods of remission, of diarrhea, the stools full of pus and blood, pain in the lower right quadrant, weight loss, anemia, fistula, fever, continuous or intermittent, up to 103° F., with a tender fixed mass in the lower right quadrant or midline.

The x-ray diagnosis is probably best accomplished with a barium enema which is so administered that there is a reflux through the ileocecal valve, allowing the terminal ileum to be visualized. With the ingested meal, the examination is more time consuming, and because in the irritable state of the involved gut the barium is rushed forward, it is not easy to catch a picture at the typical moment. The roentgen picture depends upon the stage of the process. The

lumen may be encroached on only slightly. There is irregularity in contour. Later, the ileum becomes a rigid tube with narrow lumen, and still later there are the signs of obstruction.

The x-ray findings in regional ileitis have not been completely established by any characteristic pattern. Knowing that the normal motility empties the small gut within a few hours after gastric emptying is completed, one can suspect unusual delays at the ileac coils. In early cases there may be delay only in their emptying into the cecum, with a persistent and fixed pattern of these ileac coils in a repeated examination. If the same pattern is obtained by means of a barium enema in these same coils, the regional ileitis is confirmed. Later, when ulceration and perileac edema and infiltration have occurred, the fixed pattern is a constant and the barium meal may provide a better filling at about the twelve-hour interval than the barium enema. In the female this terminal ileac condition may become fixed within the cul-de-sac of Douglas. The differential diagnosis between terminal ileitis and abscess in the pouch of Douglas should not be confusing, for in such a regional abscess there is not so likely to be any small intestinal obstruction. Furthermore, the vaginal palpation of the abscess and the elevated temperature and increased white count are not present with terminal ileitis.

E. The Appendix

In 1909 Bécélère announced that he had examined a patient in whom he had been able to visualize the bismuth-filled appendix. He predicted that improvements in technique would allow of frequent visualization of this kind, and that it would prove of great help in diagnosis in that the exact position and shape of the appendix could be known, and when the pathologic conditions of the appendix were in doubt the examiner could prove the diagnosis by eliciting tenderness exactly over the place where the appendix actually was demonstrated by x-ray.

Aside from the complete asininity of the last part of this pronouncement, it is one of the most dangerous doctrines ever promulgated. All the statisticians, living and dead, pouring over mountainous piles of graphs, would be unable to assess the misery this maneuver has caused, to enumerate the hordes of gullible and trusting human beings who have suffered in mind and body and estate when some egregious ignoramus ripped them open and removed a "chronic appendix."

That is all that needs to be said about the roentgenology of the appendix. Except, perhaps, to quote Dr. Walter Alvarez to the effect that he never saw a patient who was improved by an appendectomy under the diagnosis of "chronic appendicitis," nor one that did not have a return of the original symptoms.

Of course, when acute appendicitis is under consideration, to give a patient a barium meal or a barium enema is a pernicious procedure.

F. The Colon

The colon should be completely filled twenty-four hours after the ingestion of a barium meal. Normally it should present a solid outline, bordering the abdomen, and strikingly irregular in its outline because it is broken

up into segments or haustra. These haustrations are most evident in the transverse and descending colon. In the ascending colon, the indentations are not so deep and the segments are larger. These haustra, of course, correspond to the anatomic divisions so readily seen in the cadaver, which result from the fact that the taeniae coli, the longitudinal muscle fibers of the colon, are shorter than the colon itself. The haustrations are important from a clinical roentgenologic consideration, because when there is widespread inflammation in the colon they disappear. They are not so evident when the barium enema is given, the less evident the more distention is made by the enema.

The position of the colon may be anywhere in the abdomen, depending on the length of the mesentery, without indicating anything of clinical significance.

The head of the barium meal reaches the cecum in four and a half hours, the hepatic flexure in six and a half hours, the splenic flexure at nine hours, the ileac colon in eleven hours, the pelvic colon in twelve hours, and the rectum in eighteen hours.

The contents of the colon are propelled forward in large mass movements. During fluoroscopic examination the outline of the transverse colon suddenly disappears and with lightning rapidity its contents pass into the descending colon. At first with the force of this thrust the haustrations in the descending colon are wiped out, but soon reappear. The cecum and ascending colon then fill the transverse colon in much the same way, although such dramatic mass propulsion is not the rule.

Antiperistalsis in the ascending colon and cecum is the rule. •

The rectum is empty normally except just before defecation. The contents of the sigmoid are prevented from entering the rectum by a semivalve-like arrangement at the rectosigmoid junction. For all practical purposes it is a valve.

DISEASES OF THE COLON

Hirschsprung's Disease, Congenital Dilatation of the Colon, Idiopathic Steatorrhea, Nontropical Sprue.—Congenital dilatation of the colon has been recognized for a long time. Hirschsprung described it in 1888, the appearance of the colon in two children who had died in infancy. During life they had large distended abdomens, there was great difficulty in getting the bowels to move, with the use of all sorts of laxatives and enemas, and finally emaciation, great prostration, and death supervened. The colon was found enormously dilated over its entire length, with no haustrations. The original term, "congenital idiopathic dilatation of the colon," was the object of criticism by Hurst and W. J. Mayo, who thought the condition was due to an obstruction or valve-like impasse at the rectosigmoid junction. They likened it to cardiospasm.

With the advent of the x-ray machine the diagnosis of varying grades of the condition began to be made, followed by instances of successful surgical treatment. The diagnosis can often be made by a flat film of the abdomen without barium enema. The employment of a barium enema in these cases is fraught with some danger unless the barium is promptly evacuated. An interesting development during the past few years has been the detection of

certain cases which are apparently a hangover of this condition into adult life. They have been called idiopathic steatorrhea, and nontropical sprue (why the latter, heaven only knows). The typical patient has a markedly distended abdomen. This comes on intermittently, usually seasonally—spring and fall, or successive summers. There is a diarrhea, consisting of large fatty

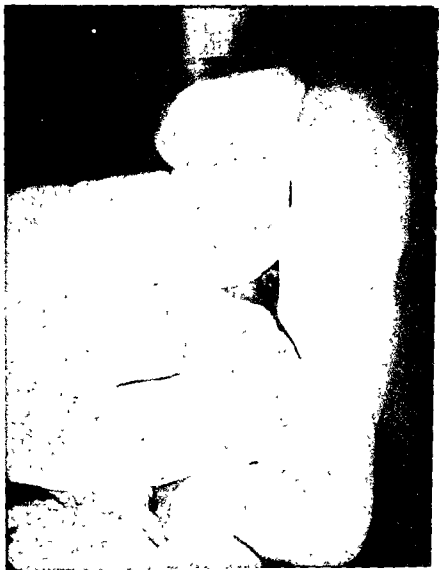


Fig. 118.—Megacolon.

stools, and also constitutional signs of hypochromic anemia, sore tongue, riboflavin deficiency, subclinical pellagra, etc. Careful investigation of the early history reveals indications of intestinal disturbance in childhood, with gradual drift into an unbalanced diet—too much sweets, or fried foods, etc. One of my patients had the history of an appendectomy for chronic appendicitis at the age of nine with no relief of symptoms.

The x-ray examination of these adults with idiopathic steatorrhea reveals a very large atonic colon with loss of haustral markings. The establishment of the diagnosis is important because these persons become chronic invalids, and are regarded as neurotics with the consequent neglect that such a diagnosis entails.

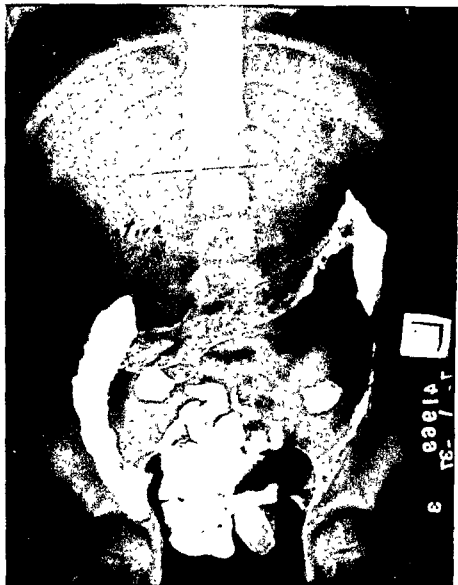


Fig. 119.—Ulcerative colitis.

Ulcerative Colitis.—In the x-ray examination for suspected ulcerative colitis the colon should be filled with a barium enema and photographed. Then the enema should be evacuated and another plate exposed.

X-ray findings in ulcerative colitis are:

1. Change in the mucosal relief. This may be a very early sign. At first, due to congestion of the mucosa, the haustral folds are wider and show irregularity. Later, due to ulceration, infiltration of the muscularis coat, and inflammatory edema, they entirely disappear and the bowel appears as a smooth-walled, narrow tube. There may be a tendency to a ribbonlike appearance.

2. As a result of the rigidity of the walls of the colon, the barium enema may fill the colon with unusual rapidity.

3. Shortening of the colon.

4. With the emptying of the barium enema ulcer craters and polyps may be seen outlined by the fragments of retained barium. This does not last long.

5. Hypermotility of the colon. The earliest sign may be such spasm of the colon that great difficulty is experienced in introducing the enema.

In the examination of cases of ulcerative colitis the clinician may occasionally have to suggest to the roentgenologist that perforation may occur, if the methods employed are not gentle.

Ulcerative colitis usually begins in the rectum and sigmoid, gradually becoming diffuse. Localized areas of involvement may occur. Bargen and Weber (*Radiology* 17: 1833, 1931) describe a group of cases in which the distribution was strictly localized in all parts of the colon. Multiple polyps are complications in 16 per cent of cases of ulcerative colitis (Logan: *M. Clin. North America* 7: 105, 1923).

Amebic ulcerative colitis presents about the same picture as nonspecific ulcerative colitis.

Intestinal Tuberculosis.—Some degree of intestinal tuberculosis is found in about 50 per cent of autopsies in patients with pulmonary tuberculosis. Sixty-one per cent of these fail to show roentgenologic evidence of it. Primary intestinal tuberculosis is confined almost entirely to children. The ileocecal area is the site of involvement in all types in 85 per cent of cases. Pathologic types are the ulcerative, the cicatricial or stenosing, the enteroperitoneal consisting of an ulcerating lesion with peritoneal and lymphatic extension and chronic hyperplastic tuberculoma.

In the x-ray examination location and size of the cecum and ileum, motility of the cecum under palpation, character and regularity of the cecal haustra, constancy of appearance on repeated examinations, abnormalities of movement along the colonic tract.

A contrast meal—barium meal first, followed by an ordinary breakfast—is the technique usually recommended.

In diagnosis, in the presence of pulmonary tuberculosis, with supervening symptoms (spells of diarrhea, tenderness) suggestive of trouble in the cecum, nearly any suspicious x-ray finding is of utmost significance.

Diagnosis depends on:

1. Filling defects, due to ulceration, tumors, or adhesions.

2. Local instability of a segment of ileum or cecum (Stierlin's phenomenon).

3. Failure of cecum to fill at all.

4. Narrowing and shrinking of the lumen.

Diverticula and Diverticulitis.—Diverticula occur in the colon more frequently than in any other part of the digestive tract. The incidence is stated at from 1 to 5 per cent in consecutive unselected autopsies. They are particularly frequent in the sigmoid. The incidence rises as age advances. Roberts (Surg., Gynec. & Obst. 26: 211, 1918) says that every pot-bellied individual over sixty is likely to have multiple diverticula of the colon, particularly if there is a history of long-standing constipation. They are prone to occur at the mesenteric border and correspond to areas of penetration of vessels through the muscularis. The age incidence and the site would indicate that they are acquired rather than congenital anomalies.

The diagnosis has been greatly facilitated by the use of the x-ray-examination.

Visualization of diverticula may be very easy or present considerable difficulty. The location, narrowness of the neck preventing barium from entering the diverticulum, and filling of the diverticulum with fecal material may constitute the difficulties. When there are symptoms indicative of their presence, additional procedures to supplement the ordinary barium enema proceedings may be utilized: a thin barium enema is used and after plates are taken it is evacuated and another plate taken; in the latter plate the diverticula are likely to stand out in clean relief. An ingested meal by mouth may bring them out.

Inflammation, especially of the sigmoid diverticula, is a rare but serious complication. It occurred in 5.89 per cent of the Mayo series of 26,699 cases of diverticula (x-ray evidence). Ordinary clinical experience would suggest that this figure is high.

Our knowledge of sigmoid diverticulitis is unsatisfactory as regards both diagnosis and treatment. Feldman states, "The roentgen diagnosis of diverticulitis is by no means as easy as one may be led to expect. . . . It may be difficult, and at times impossible, to distinguish between diverticulitis and diverticulosis."

In the early stages the descending colon may present a peculiar saw-tooth appearance due to partial obliteration of the haustra. It looks rather like a pile of biscuits viewed from the side. Other signs are fixation of the involved bowel, localized hyperirritability and hypermotility. Obstruction may occur in which case the entrance of the barium enema is stopped: the obstruction and stenosis are seldom complete. The fluoroscope may guide the examining hand to the tumor or the localized tenderness. A characteristic feature of the tumor is its variability. Appearance and subsequent disappearance of the tumor are the most reliable signs of diverticulitis.

Differential diagnosis must consider carcinoma first, then extra sigmoid conditions, such as phlebitis, calcified glands, urinary calculi, appendiceal and pelvic abscess.

Lymphogranuloma inguinale is a venereal disease caused by a filtrable virus which produces a transient and insignificant lesion on the genitalia, but which invades the skin of the inguinal region and the rectum, with very serious and

destructive consequences. Cole reported 110 cases from one hospital service in a three-year period, and Lichtenstein estimated that 400 cases a year applied for treatment at the New Orleans Charity Hospital.

In the rectum and sigmoid the disease produces strictures. The x-ray picture is not particularly specific: the process is diffuse with narrowing of the anorectal region. The rectum and sigmoid become rigidly tubular, and fistulous tract formation is common. A contrast enema, first barium and then air, may be of service.

Polyps of the Colon. Polyposis of the Colon.—The term polyp is used to indicate any benign sessile or pedunculated growth. It applies to tumors which may be histologically fibroma, adenoma, lipoma, myoma, or angioma. The incidence is variously reported on autopsy material as from 0.7 to 19 per cent. Clinically significant cases must be few and far between, if my experience is any criterion. In distribution they may occur in any part of the intestine—the ileum, colon, or rectum, most frequently in the rectum, sigmoid, and splenic flexure. They are multiple in the great majority of instances. A marked familial tendency is notable.

Malignant degeneration of intestinal polyps is the rule. Mummery believed that all recorded cases of polyposis became malignant. Soper puts the figure at 43 per cent.

Polyps on the ileac side of the ileocecal junction predispose to intersusception.

The x-ray diagnosis of polyposis, as is the case with all benign tumors of the colon, requires the double contrast method of examination. Thorough cleansing of the bowel with castor oil the night before and irrigation of the colon on the morning of the examination are essential. The double contrast method consists in giving the barium enema, making roentgen observations and plates, evacuating it, and then giving a direct insufflation of air into the colon, after which further observation and plates are made. The exact technique need not concern us here.

With the barium enema in place, the opaque media is likely to obscure all traces of polyps. There may be a filling defect (of the punched out variety), or a serous, if translucent, area where the polyps have clustered in one spot. After evacuation and air insufflation, flecks of barium cling to the polyps and render them plainly visible.

Benign tumors of the colon include myoma, fibroma, hemangioma, dermoids, cholesteatoma, and endothelioma. The x-ray diagnosis is not specific and depends on a filling defect or outlining the tumor by the double contrast method (see Bargen and Dixon: *Am. J. Digest. Dis. and Nutrition* 1: 400, 1934).

Carcinoma of the Colon.—Larson and Nordland (*Am. Surg.* 100: 328, 1934) found that out of 21,648 consecutive, unselected general clinical cases examined there were 723 instances of cancer of the digestive tube: of these 42 occurred in the mouth, 57 in the esophagus, 399 in the stomach, 11 in the small intestine, and 214 in the large intestine and anus. Cancers of the large intestine show a marked predilection for those areas in which delay or stasis is common—the

flexures and narrowed segments; 50 per cent of colon cancers are in the sigmoid. The splenic flexure is more frequently involved than the hepatic flexure.

Pathologically colon cancers are classified as medullary or adenocarcinoma, scirrhous, colloid or mucoid, and those arising on polyps. They metastasize slowly and late.

A palpable tumor occurred in 10 per cent of Lahey's cases (*Am. J. Surg.* 22: 64, 1933), and 36.6 per cent of Abell's cases (*South. M. J.* 26: 64, 1933).

The x-ray information is all important. The reliability of the x-ray in the diagnosis of cancer of the colon is stated by various roentgenologists to be from 75 to 95 per cent.

The roentgen signs will vary, depending upon whether there is or is not obstruction. It is naturally in the early stages that the largest number of x-ray failures will occur. Repeated examination, with the patient in the erect as well as supine position, should be made in all doubtful cases. The double contrast technique, mucosal relief, the routine barium meal by mouth as well as the barium enema should be employed.

The x-ray signs of carcinoma of the colon are:

1. Filling defect—(a) annular, napkin-ring type, (b) cauliflower, (c) irregular.

2. Obstruction—slight, partial, complete. The barium enema makes the obstruction look greater than barium given by mouth. Particularly is the lesion fulgurating. It may form a cone so that the contents of the bowel pass through readily enough from above, but when the flow is started the other way there is a valve effect.

3. Dilatation of the colon proximal to the obstruction.

4. Obliteration of haustra near and around the tumor.

5. Spasm.

6. Complications—fistula, etc.

Differential Diagnosis.—Sigmoid diverticulitis is the condition most likely to be confused with carcinoma on account of the identical age incidence, site, and similar x-ray appearances. Carcinoma may be associated with diverticulitis in only about 5 per cent of cases—a valuable differential point.

Other conditions that may cause confusion are: (1) spasm, (2) extra colonic conditions—peritoneal abscess, pelvic tumors which encroach on the lumen of the colon, (3) benign tumors, (4) syphilis, (5) lymphogranuloma, (6) Hodgkin's disease, (7) fecal impaction, (8) adhesions, (9) actinomycosis, (10) ulcerative colitis.

Constipation.—The greatest service that x-ray examination can perform in constipation is toward the education of the patient. The patient is warned against the use of a cathartic during the period of examination. Since, in most instances, he has been using cathartics daily, this prohibition seems almost equivalent to a sentence of death. He is not allowed to have a cathartic for three days. By that time he usually has a spontaneous bowel movement, an event which fills him with wonder and delight. He talks about it for days, as if it

were a miracle. He is halfway persuaded to give up the cathartic habit. So the first rule for the patient with constipation is to prolong the examination until a spontaneous evacuation has occurred. Even if the wait is so long that the barium has become hardened and assistance is required to remove it, the fact that a spontaneous defecation is initiated is of great moral value.

Aside from that the x-ray examination is valuable in eliminating any organic cause for the constipation. It, of course, provides a timetable for the meal in the intestines which may or may not be valuable. Wallace et al. (Motility of the Gastrointestinal Tract, Am. J. Roentgenol. 39: 64-66, 1938) found that the normal colon may take as long as 120 hours to empty. The largest number of their subjects (65 per cent) evacuated the meal completely in 72 hours. A small group (7.8 per cent) evacuated the meal completely in 24 hours.

Fleiner popularized the idea of *atonic* and *spastic* constipation. These terms describe the tone of the colonic musculature. With *atonic* constipation there is general lack of propulsive force. With *spastic* constipation, the lack of forward movement is ascribed to spasm of the colon: spastic constipation is characterized clinically by small fragmentary stools and spasticity of the sphincter ani. The "spastic" conception never appealed to me as having any foundation in reality: spasm under all known conditions is associated with pain and diarrhea.

But although the "atonic" conception, simply a lack of response on the part of the colonic musculature to the impulse to propel the contents of the colon onward, fits in with the symptoms and all the circumstances of the average case of constipation, the x-ray evidence requires some modification of it. In a careful study of any case of constipation it becomes evident that the stasis is localized in one segment rather than general.

The first x-ray study of constipation was that of Hurst (*Constipation and Allied Intestinal Disorders*, Oxford University Press, 1911). When I read the book on its first appearance and afterwards visited Hurst's clinic at Guy's Hospital, I was much impressed with his description of the form of constipation known as "dyschezia." Perhaps I was the more impressed by it because in another part of Guy's Hospital there was on exhibit the ghastly and sickening sight of Dr. Arbuthnot Lane removing the entire colon in cases of constipation. Dyschezia, according to Hurst, is a form of constipation in which the point of delay is actually in the rectum itself: through habit of neglect of the call to stool it has lost its sensitivity and response, and feces simply accumulate there. Later it was shown that the so-called toxic symptoms of constipation—headache, etc.—could be initiated by stuffing the rectum with cotton. The treatment was logically to restore the sensitivity of the rectal mucosa by emptying the rectum by enema. As time has gone on, I have found fewer cases of dyschezia, but still I think it exists and should be kept in mind.

Another large group of cases shows the descending colon empty and the fecal mass stuffed at the splenic flexure. This has been called spastic constipation, but it may well be atony of the muscles of the transverse colon. Stasis in the cecum also occurs.

Enteroptosis may be a cause of constipation. On the contrary, we often see cases of extreme enteroptosis with the colon entirely in the pelvis with no functional disturbance whatever. X-ray pictures of enteroptosis are likely to be clinical booby traps.

Mucous Colitis.—The usual x-ray picture of mucous colitis is that of spasticity of the colon. The barium may become embedded in strings of mucus, giving the so-called string sign.

G. The Gall Bladder and Ducts

The x-ray diagnosis of gallstones and especially gall bladder disease was for practical purposes nonexistent until the genius of Evarts Graham, in 1924, raised it to a scientific status. Graham discovered a dye which is concentrated by the mucosa of the gall bladder, allowing visualization of that structure. Dr. Graham (First Walter C. Alvarez Lecture, before the American Gastro-Enterological Association, Atlantic City, May 6, 1930, published in the *American Journal of Surgery*, May, 1931, and in the *Journal of the Missouri State Medical Association*, September, 1931) has recounted the steps which led him to make his inspirational discovery and they are so illuminating that I take the liberty of quoting them:

"It is difficult to recall how the idea of the possibility of visualizing the gallbladder by the use of phenolphthalein derivatives presented itself. On several occasions a former member, the late Walter Mills, and I had spoken of the desirability of visualizing the gallbladder in some manner comparable to the visualization of the stomach and other parts of the alimentary canal. No satisfactory method, however, suggested itself until suddenly one evening in the winter of 1922 the idea occurred to me that, since Abel and Rowntree had demonstrated the fact that the chlorinated phenolphthaleins are excreted almost entirely through the bile, it might be possible to obtain a shadow of the gallbladder by substituting for the chlorine atoms other atoms which would be opaque to the x-ray.

"Acting on this suggestion I began to consult catalogues of various manufacturing chemical firms to see if I could obtain some phenolphthaleins containing bromides or iodine atoms which were already prepared. If I had been unable to obtain any from the manufacturers I intended to attempt the preparation of some of them myself, or to have them made under my direction. However, I was able to obtain some of the free acid of tetraiodophenolphthalein from the Eastman Kodak Company. This was advertised in a list of various indicators. After receiving the material I turned it over to Warren Cole in July, 1923, and asked him to inject it into some animals to see if he could visualize their gallbladders with it. Dr. Cole had just completed serving his residency in surgery at the Barnes Hospital, and had become a member of the department as an assistant in surgery. Before injecting the material into dogs we converted it into the sodium salt because the free acid was naturally less soluble than the sodium salt. Six dogs were injected intravenously, and x-ray photographs were made of the gallbladder regions in all of them at frequent intervals after the injection. In five of the dogs no shadow was obtained, but, fortunately, a faint shadow was obtained in the sixth dog. At first we were at a loss to understand why we had obtained a faint shadow in one dog, but none at all in the other five animals. The idea then occurred to us that the reason for the failure was probably due to the fact that the animals were not fasting and

that, therefore, the injected substance was not staying in the gallbladder for a long enough time to be concentrated and, therefore, to make a shadow. From the standpoint of the future development of cholecystography we often feel grateful to that one dog which cast a shadow, probably because he was accidentally given no food. If we had failed to get a shadow in all of these animals we probably should have abandoned the whole idea as a fruitless one. It is curious on how fragile a thread the destiny of some events hangs. When we came to investigate the matter we found that, as a matter of fact, through some mishap the animal keeper during the time of the experiment had for some reason neglected to feed the one dog on the morning of the injection, but he had fed all of the others. Greater efficiency on the part of the animal keeper would doubtless have resulted in a complete failure of our experiment and, therefore, we would have given up the whole idea. Sometimes efficiency can be a curse.

"With the clue that the failure to cast a shadow was due to the presence of food in the stomach and duodenum it was then relatively simple to determine that we could obtain shadows in almost every instance in our experimental animals if we were careful to make the injections during a fasting period. Problems of dosage then came up and it was necessary to make a large number of injections in order to determine what would constitute a safe dose for the human being. At about this time Glover H. Copher, another member of the department of surgery, was added to the group conducting the investigation. The problem was particularly complicated because of the fact that in several instances our experimental animals died after receiving injections which were considerably smaller than those which had been given to other animals that survived. There was also present before us the well-known fact that organic iodine compounds are in general much more reactive than their bromine homologues. This fact made us turn hopefully to the bromine compound, although, of course, we could predict that the dose of it required to give a shadow of comparable density would be larger than that required for the iodine compound because of the greater atomic weight of the iodine. Accordingly we enlisted the services of the Mallinckrodt Chemical Works, of St. Louis, who, very generously, put at our disposal one of their chemists to make a large number of preparations for us. We were eager to try various bromine and iodine substitution products, not only of phenolphthalein, but also of other substances which might have possible advantages. We were also interested in knowing whether a more complete saturation of the phenolphthalein molecule with iodine or bromine, such as, for example, an octaiodo compound instead of a tetraiodo compound might have greater advantages because of the much greater amount of iodine contained in the molecule. At all events the Mallinckrodt Chemical Works finally supplied us with an exceptionally pure product of the sodium salt of tetrabromophenolphthalein. We injected this material into animals and found that we got good shadows of the gallbladder with much less toxic effects, in spite of the larger dose required, than we had previously obtained from the use of the tetraiodophenolphthalein which we had obtained. This fact made us feel that for the time being it would be safer to use the bromine compound for human beings than the iodine product.

"Up to that time our only idea in visualizing the gallbladder had been to introduce something into it which would visualize any contained stones or deformities of the organ. A colored woman in the Barnes Hospital who presented a very characteristic clinical picture of gallstones seemed to present satisfactory conditions for the first trial in the human. We carefully calculated what the proper dose of the substance would be if injected into her and we gave her the calculated amount of the sodium salt of tetrabromophenolphthalein. I may say that Mills was much interested in the outcome of this first trial on the human of this material and we all had great hopes that we would be able to get a sharp

image of gallstones in the woman's gallbladder. An ordinary x-ray film before the injection of the dye had failed to show any stones. To our great disappointment and consternation the patient showed no shadow at all of her gallbladder after injection, in spite of a series of films which were made. Our disappointment was made more intense by the fact that I operated upon this patient and found a gallbladder which contained many stones of different sizes. It seemed to us, therefore, for the moment, as if our high hopes of improving the diagnosis of gallbladder disease had been dashed to the ground. Soon, however, the idea occurred to us that since we had been obtaining excellent shadows in our experimental animals, which presumably had normal gallbladders, the reason for our failure to produce a shadow in a markedly diseased gallbladder might be because the diseased gallbladder could not properly concentrate the material which was brought to it. We also, of course, took into consideration the possibility that in the diseased gallbladder there might have been an obstruction of the cystic duct which prevented the entrance of the material into the organ, but in the case in which we had had a failure I had found an abundance of bile in the gallbladder at the time of operation and also no evidence suggestive of an obstruction of the cystic duct. We were, therefore, forced to believe that a diseased wall in itself might be sufficient to result in nonvisualization because of the failure of concentration. This conclusion seemed to be an obvious one to draw from the work of Rous and McMaster on the concentrating function of the normal gallbladder.

"This conclusion led us to the next step, which was to inject some patients who supposedly had normal gallbladders. We were gratified to obtain well visualized gallbladders in two or three such individuals. This result, while gratifying, made it necessary to change our whole conception of the possible applicability of such a test to the patient. For, instead of having a method which would with certainty reveal gallstones in the x-ray picture we found that we were, on the contrary, dealing with a method which was more of a functional test of the gallbladder and one which would show the gallbladder most plainly under normal conditions, and not at all in those conditions in which the organ was very badly diseased no matter whether stones were present or not. The recognition of the fact that this new method of visualization of the gallbladder was really a functional test was brought out in most of our early writings on the subject and we were, therefore, amazed to discover how many years were required before there was more or less general recognition of this fact. The oral method of administration of the dye is, since its introduction, the method of choice. It is usually given in repeated doses; this gives a cumulative effect: sometimes with a single dose the gallbladder would not be visualized and yet be found normal at operation.

"The underlying mechanism of visualization of the gallbladder after administration of the dye depends on the function of the gallbladder of concentrating the dye as it does the bile."

The gall bladder goes through continuously recurring cycles, each cycle consisting of three stages: a period of slow filling, a period of slow emptying, and a collapsed or resting period. Protein or carbohydrate food cause no gallbladder response. Fat in any form in the intestines empties the gall bladder in about one hour. The studies of Copher (J. A. M. A. 84: 1563, 1925) indicate that the dye enters the gall bladder by way of the cystic duct.

Certain conditions are assumed before interpretation of gall bladder shadows. These exceptions are vomiting of the dye, diarrhea, fat in the bile, all of which interfere with absorption or retention of bile in the gall bladder.

Of course, there are the precautions against eliminating fat from the diet and introducing of cathartics during the test. The dye is very likely to cause nausea and vomiting and catharsis.

In general, it may be said that with a normal gall-bladder mucosa and no obstruction of the cystic duct, the gall bladder will be visualized in all instances when the dye is absorbed in sufficient concentration. This, indeed, is the simple principle of all cholecystography. The size, shape, position, contour, and mobility of the normal gall bladder vary within quite narrow limits. The contour is notably smooth. The emptying rate of the gall bladder is determined after visualization, by the administration of a fat meal. Half an hour later the gall bladder should be diminished in size about 50 per cent.

All degrees of visualization will be encountered. Complete lack of visualization means widespread disease of the gall-bladder mucosa with or without stones, or cystic duct obstruction. But with moderate retention of function and with cholesterol and pigment stones, the gall bladder and the stones can be clearly visualized.

Persistence of the shadow after a fat meal indicates a pathologic gall bladder, although Moore (J. A. M. A. 95: 1957, 1930) thinks the diagnostic importance of persistence of the gall bladder shadow has diminished to the vanishing point.

Gallstones are either pure cholesterol, or 75 to 95 per cent cholesterol with calcium, or cholesterol and bile pigment (the commonest form), or bilirubin-calcium stones (which can usually be visualized on a flat plate or without the use of the dye).

With proper technique and interpretation cholecystography is at least 95 per cent accurate in the diagnosis of gall bladder disease. In fact the cholecystographic technique has become so refined that Kirklin has reported a series of benign tumors of the gall bladder diagnosed as such and verified by surgery. It requires meticulous technique to show the lesions. They usually are seen as nonopaque areas along the border in the film made after emptying has been promoted by a fatty meal. Stones may move, but these small tumor masses are constant in their position in the visualized gall bladder. (Kirklin: *Am. J. Roentgenol.* 25: 46, 1931, and *ibid.* 29: 8, 1933.)

Cholangiography.—*Visualization of the gall ducts may show calculus in the common duct, generalized dilatation of the biliary tree, and other abnormalities. It is valuable as a postoperative procedure in the presence of persistent biliary fistula, the contrast substance being injected into the fistula. The contrast substances used are lipiodol, umbrathor, hippuran or thorocontrast.*

Visualization of the liver and spleen by thorocontrast or by some other substance not yet found holds possibilities of great moment, but the use of thorocontrast is not without danger. It is deposited in the reticulo-endothelial cells and may remain so deposited for years, destroying their function.

Pneumoperitoneum.—Air can be introduced into the peritoneum and is an excellent contrast medium to show up the liver, spleen, attachments and position of the abdominal organs, and various pathologic conditions. There are few occasions, however, when it is useful, and the introduction of the peritoneoscope

has largely displaced its employment. The presence of subphrenic abscess and the differentiation of extraperitoneal from intraperitoneal masses are the conditions for which most help is claimed through the use of pneumoperitoneum.

V. X-RAY DIAGNOSIS OF DISEASES OF THE KIDNEYS, URETERS, AND BLADDER

Calculi.—Stones may occur in any location in the urinary tract. Ninety-seven per cent of them are composed of inorganic material and, therefore, throw a shadow on the x-ray plate. They vary in size from small particles, like sand, to enormous concretions as big as the hand or fist. Large stones in the kidney may penetrate the calices and produce a perfect cast of the pelvis. Eighty-three per cent of calculi found at operation was detected by the x-ray.

Differential diagnosis of kidney or ureteral stones mostly is concerned with the interpretation of extraneous shadows in the region of the kidney, pelvis, or ureter. These may be:

1. Gallstones—calcified gallstones may easily be mistaken for pelvic stones on the right side.
2. Calcification of the portal cartilages.
3. Calcified mesenteric lymph nodes, particularly troublesome in the case of suspected impacted ureteral stone.
4. Fecaliths—ditto.
5. Phleboliths—ditto.
6. Warts and moles in the skin.
7. Artifacts on the screen or plate.

Retrograde pyelography has served to render many kidney, ureteral, and bladder diseases very easy of diagnosis. It has even created a good many pathologic pictures of doubtful authenticity. In this field the internist and the radiologist are in the same position as regards the urologist as they often are with the dentist; they must restrain his enthusiasm for operative interference following the demonstration of mechanical or anatomic deviation from an ideal norm, especially as regards the *ptotic kidney*.

Retrograde pyelography will never be replaced by intravenous injections. If the patient is carefully prepared by withholding fluids for at least eighteen hours, removing intestinal gas by enemas, or, if that is contraindicated, by pitressin, most acceptable evidence as to the functional and structural integrity of the kidneys and ureters can be obtained by the intravenous method. This examination requires meticulous attention and even so performed it is not in itself sufficient to study a patient in whom a tuberculous kidney is suspected. The hypertensive patient is particularly well studied by intravenous pyelography, and it is a simple procedure to rule for or against a contracted kidney, obscure obstruction, etc.

With the introduction of a contrast medium the ureters, kidney pelvis, and bladder can be clearly outlined. Normally the following structures are found:

The kidney pelvis has three major calices, each of which drains clusters of two, three, or more minor calices.

The ureters vary within a wide range of normality. They are located parallel with the lumbar spine at about the outer margin of the transverse processes of the vertebrae. There are three points of natural constriction of the ureter: at the junction of the kidney pelvis and the ureter, as the ureter crosses the brim of the bony pelvis, and at the junction of the ureter and bladder.



Fig. 120.—Huge stone in right kidney pelvis with hydronephrosis.

The following pathologic conditions can be made out by contrast media:

Dilatation of the Kidney Pelvis.—Any obstruction in the flow of urine will eventually obstruct the kidney pelvis. As the obstruction continues the lower level of the kidney pelvis sinks lower and lower, causing stagnation of the urine which eventually inevitably leads to infection. Simple dilatation is known as hydronephrosis. Dilatation with infection is pyonephrosis.

Ptosis of the kidney and kinking of the ureter with or without Dietl's colic.

Distortion of the kidney pelvis and calices occur in kidney tumors. The tumor by enlarging the cortex of the kidney may draw out the calices to slender

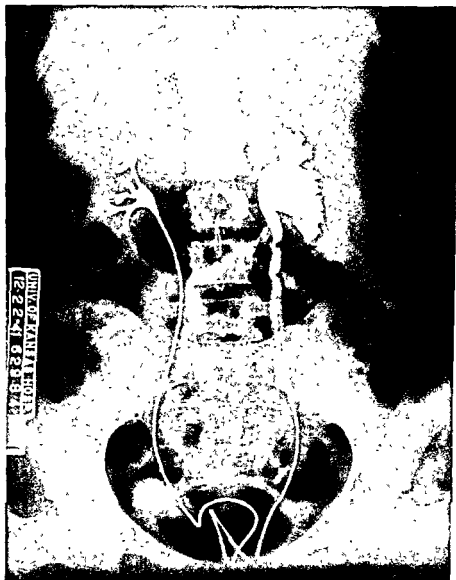


Fig. 121.—Hydronephrosis.

fingerlike projections. Cysts of the kidney, as well as neoplasms, may project into the pelvis, obliterating one or more calices. Pedunculated tumors also may encroach on the pelvis. The x-ray changes produced by kidney tumors are entirely nonspecific. The type of tumor present cannot be diagnosed by this means.

Polycystic kidney presents an enlarged kidney shadow with an irregular nodular outline. The pelvis is large in extent, but small in capacity. The pressure of numerous small cysts on the pelvis and calices produces a very characteristic spiderlike narrowing of the major calices and flaring of the cusps of the minor calices. The condition is bilateral in 80 to 85 per cent of cases.



Fig. 122.—Hematuria. Double ureters. Tumor of upper pole of right kidney.

Cortical Necrosis.—A tumor of the kidney may become necrotic in the center and discharge its necrotic material into the kidney pelvis, leaving an irregular cavity extending from the pelvis into the cortex of the kidney.opaque media entering the pelvis will find its way into this cavity and readily be visualized. Such "cortical necrosis" is present in tumors, abscess of the kidney, and tuberculosis of the kidney.

Tuberculosis of the kidney may also be recognized by the presence of numerous calcifications in the kidney substances. The diagnosis of tuberculosis of the kidney is not adequately made by intravenous pyelography. If from findings of an intravenous examination tuberculosis is suspected, it should be verified or reconciled by retrograde filling via cystoscope.



Fig. 123.—Tuberculosis of kidney. Ulceration in all the calices.

Anomalies of the kidneys and ureters are, of course, very readily indicated on the pyelogram. Horseshoe kidney, single kidney, double ureter, and many other minor variations can be seen.

X-ray pictures of the bladder filled with contrast media show new growth filling defects, diverticula, and stone.

VI. X-RAY EXAMINATION OF THE CENTRAL NERVOUS SYSTEM

Encephalography, Ventriculography, Myelography

In the presence of possible intracranial tumor a plain x-ray picture may occasionally show some changes of diagnostic value. The commonest of these—bony erosion of the sella turcica by the growth of a pituitary tumor—has already been mentioned. (See p. 685.) Tumors of the middle posterior fossa may cause rarefaction of the petrous bone. Eighth nerve tumors may expand the auditory canal and inner auditory meatus. Gliomas of the optic nerve will expand the optic canal. Prolonged pressure within the skull produces convolitional atrophy, excessively deep configuration of the convolutions of the bone.

But such help as the x-ray gives by taking ordinary plates is rare and unimportant. With the introduction of ventriculography and encephalography, the usefulness of the x-ray picture has been greatly increased. By lumbar puncture the fluid can be drained and air can then be introduced through the needle to outline the ventricles and spinal canal in a beautiful fashion. The most helpful pictures are:

1. Great enlargement of the ventricles in hydrocephalus; it can be seen in lateral and anteroposterior views. The cerebral cortex is thinned out to a shell.
2. Displacement of one or the other lateral ventricle by tumors growing on one side.
3. Filling defects caused by tumors.
4. Subarachnoid pathways can be seen as fine tortuous irregular channels at the periphery of the cranial cavity. They are obliterated sometimes by hematoma and in epilepsy.
5. Cortical necrosis can be seen by escape of air from the ventricles into the necrotic area.
6. Spinal block may be seen in the spinal canal caused by spinal cord tumor or by herniated nucleus pulposus or extending beyond the spinal canal, but obstructing the entrance of air into the ventricles by subtentorial tumors.

The use of control media, such as iodized oil, injected into the cerebrospinal canal has always been criticized on the ground that it may harm the central nervous tissues. Definite proof of this is lacking, but the media stays in the canal for a long time, and the fact that its presence can be demonstrated years after the injection leads to litigation and damage suits. Air injections (intra-spinal) will show sizable herniation of the nucleus pulposus.

Chapter 27

THE ELECTROCARDIOGRAM

Interpretation of Electrocardiogram

Step I.—

- a. Errors in the technician's office. (Technicians sometimes make mistakes.)

Is this the electrocardiogram of the patient you have under consideration?

Are all leads present—I, II, III, and IV (chest leads)?

Is the potential going in the right direction or are the waves upside down? (This has happened several times to me; it gives a very bizarre picture.)

- b. Are any artifacts present?

- c. Brief clinical history of the patient—age, chief complaint, duration since onset, chief physical findings.

Step II.—Determining the heart rate by the spacing of the R R interval (4 large spaces = $4/5$ of a second or a pulse rate of 72). Are all R R intervals equal?

Step III.—Determine P-R interval (normal 0.16 second).

Step IV.—Determine R-T interval (normal 0.08 second).

Step V.—Determine Q T interval (normal 0.36 second).

Step VI.—Duration of QRS (normal 0.08 second).

Step VII.—Direction of QRS in Leads I and III. Is there right ventricular preponderance? Is there left ventricular preponderance?

Step VIII.—Study T wave. Upright or inverted in Leads I, II, III and IV.

Step IX.—Duration of QRS T segment. Take off of QRS T segment

“The basic principle of the electrocardiogram is simple. Whenever a cell is activated, be it one which conveys a nerve impulse or a muscle cell which contracts, a difference in electric potential is set up between the activated portion of the cell and the resting part, which can be detected by placing electrodes on the cell and registering the change by a sufficiently delicate galvanometer. Where a great number of such cells are involved, as in the heart as a whole, the record which is obtained is a summation of these electrical stresses registering in succession the phases of the cardiac cycle. The magnitude of the changes is a measure of the degree of unbalance of the stresses and not a measure of the mechanical force of the heart beat.” (Laurence B. Ellis: *Electrocardiography in General Practice*, New England J. Med. 222: No. 26, June 27, 1940.)

Four tracings known as Leads I, II, III, IV are presented to the clinician. These represent tracings when the electrodes are on the right arm and the left arm—Lead I; right arm and left leg—Lead II; left arm to left leg—Lead III; the chest lead Lead IV—with one electrode over the apex of the heart and the other either on the left leg (I v F) or right arm (I v R).

Each lead consists of a number of waves representing some contraction or relaxation phase of the cardiac cycle. They have been lettered P, QRS, T, and U. P represents the auricular contraction, QRS represents the incitation of ventricular contraction, T is coincident with the ventricular diastole, and though there has been considerable controversy as to its meaning, it is taken to measure the subsidence of ventricular activity. Study of the S-T segment is particu-

larly important as recording the myocardial state in ventricular contraction. The U wave is not often well seen. While its meaning is obscure, Nahum and Hoff (*Am. Heart J.* 17: 585, May, 1939) interpret it as the end part of the ventricular complex in which the supernormal phase occurs.

Each of the waves has an average duration, measured on the electrocardiographic record against horizontal markings, and an average amplitude, measured against vertical markings.

The P wave has a duration of 0.10 second or less, amplitude 1.0 to 3.0 mm. in Leads I, II, III. It is usually inverted and notched in Lead IV.

STEP-2

DETERMINE THE SPACING OF THE RR-INTERVAL
ARE ALL RR-INTERVALS EQUAL?

LEAD I

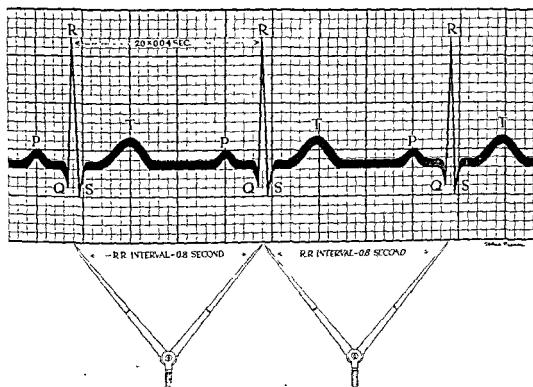


Fig. 121.

Figs. 124 to 140—Interpretation of the electrocardiogram.

The P-R interval has a duration of 0.12 to 0.20 second on the average. This represents the time required for transmission of cardiac impulse from sinus node to ventricles.

The QRS is upward in Leads I, II, III (down in infarcts), has a duration of 0.08 second, and an amplitude of 5.0 to 16.0 mm. In Lead IV it may be diphasic with the first phase downward, amplitude 8 to 32 from bottom of first to top of second deflection.

The S-T segment varies in duration with the heart rate, usually about 0.32 to 0.4 second.

T wave is upward in Leads I, II, and III; 0.01 to 0.20 second in duration, and 1.0 to 5.0 mm. in amplitude. In Lead IV it is upright and 2 to 8.0 mm. in amplitude.

Value of the Electrocardiogram

The electrocardiograph has taught us nearly all we know about the disturbances of function in the heart muscle that accompany such irregular heart action as that resulting in sinus arrhythmia, extrasystoles, auricular flutter, auricular fibrillation, heart block, and paroxysmal tachycardia. So much, indeed, has it taught us that the clinician who has taken the trouble to learn what the electrocardiograph has to teach, can usually make the diagnosis of the nature of irregular, rapid and slow pulses, without the use of the instrument, on physical examination alone. In certain conditions the electrocardiograph gives unique information.

STEP-3

LEAD I

DETERMINATION OF THE PR-INTERVAL

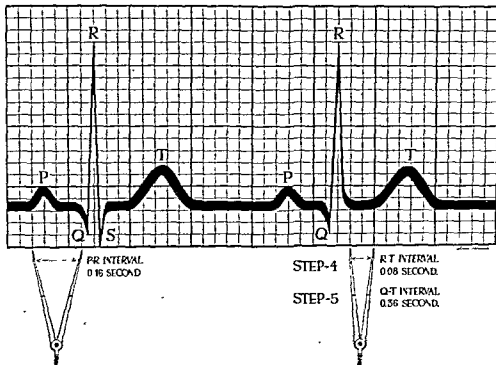


Fig. 125.

In interpreting the action of drugs (especially digitalis) to ascertain full dosage, avoid overdosage, etc., and in the interpretation of precordial pain to determine whether any myocardial infarction or other myocardial damage has occurred, the electrocardiogram often furnishes information that is final, and which can be obtained in no other way. In the first condition mentioned, it indicates better than any other method the first indications of full digitalis dosage;

in the second condition it lends great, if not final, weight to the decision of whether or not thrombosis and infarction have occurred.

For confirmation then, or final decision, the electrocardiogram should be used in all cases of irregular, slow or very rapid pulse, in digitalis and quinidine therapy, and in the presence of substernal pain or other symptoms suggestive of coronary accident.

A clear understanding of the nature and conduction of the muscular contraction and diastole of the heart is essential to electrocardiographic interpretation. The heart muscle contracts rhythmically and all the muscular units of the heart are normally coordinated. The impulse begins at the sino-auricular node (node of Kieth and Flack) which lies behind in the sulcus of the junction of the superior vena cava in the auricle. From the S-A node the impulse moves over the auricle, whether along definite muscular pathways or simply over any muscle according as it is (electrically) receptive, is not definitely settled. It ends at the auriculoventricular node, or node of Tawara, in the lower portion of the auriculoventricular septum. From this, the impulse follows along the bundle of His which divides into the right and left bundle branch, ending in the Purkinje system of fibers which ramify as a network all through the ventricular musculature, sending out the impulse to contract to all fibers.

This classic explanation was questioned when Glomset (Proc. Inst. Med. Chicago 3: No. 15, June 15, 1941) stated that after many dissections he was unable to find a definite bundle of muscle fibers corresponding to the bundle of His, nor branch bundles, by naked eye dissection. He stated that Purkinje himself found his fibers in sheep, cattle, and horses, but not in man or dog. Glomset also found "a distinct Purkinje system, which is entirely ventricular: and that it consists of a node of Tawara, a trunk with its two main branches" in ungulates, but concludes that a special conduction system does not exist in the heart of either dog or man. The contraction impulse in the human heart, if these conclusions are accepted, must pass over the muscle fibers generally rather than a special system.

There is no question that His found, or thought he found, a definite auriculoventricular bundle in the human heart, as witness his original description (Arch. a. d. med.-klin. zu Leipzig 14-49, 1893):

"After prolonged investigation I have succeeded in finding a muscular bundle that connects the auricular and the ventricular septums. This has hitherto escaped observation because, on account of its small dimensions, it is visible in its entire extent only if this area is cut lengthwise. Up to the present time, I have been able to trace the course of the bundle in such sections and also in serial sections in a grown mouse, a newborn dog, two newborn infants and one adult (thirty years) human being. The bundle arises from the posterior wall of the right auricle near the auricular septum in the atrioventricular groove, continues along the upper margin of the ventricular septum with frequent interlacing of the muscle fibers of the two structures, and then runs forward until, near the aorta, it forks, dividing into a right and left branch."

It is difficult for the clinician to give up the conception of a definite pathway for the conduction of the muscular impulse of the heart: the electrocardi-

ographic evidence for it is overwhelming. For practical purposes he will probably continue to interpret electrocardiograms on that basis

The abnormalities which the electrocardiogram is capable of revealing are:

Ventricular Preponderance.—Hypertrophy of the left ventricle or left ventricular preponderance is shown by an upright QRS complex in Lead I and a predominantly downward deflection in Lead III. The T wave in Lead I is often inverted. Hypertrophy of the right ventricle or right ventricular preponderance is shown by a predominantly downward deflection of the QRS complex in Lead I and upright QRS in Lead III.

Strictly speaking, left ventricular preponderance is interpreted when R_1 is upright and S_3 is downward. (Instead of saying the QRS in Lead I is upright, etc.) Left axis deviation is shown when S_2 is of greater amplitude than R_2 . This is said by many observers to be very rare and to mean left ventricular preponderance, but Faulkner and Duncan (Am. J. M. Sc. 208: No. 2, Aug., 1944) state that the finding in an otherwise normal electrocardiogram is to be regarded as a normal variation, which though encountered with increasing frequency with advancing age, cannot be correlated with ventricular enlargement, coronary or myocardial disease.

DISTURBANCE OF RHYTHM

Sinus Arrhythmia.—Respiratory arrhythmia, or vagal arrhythmia, is a common, almost normal, arrhythmia in childhood and youth. The pulse is faster during inspiration than in expiration. The individual waves do not deviate from the normal, nor is the origin of the impulse or the conduction mechanism essentially different from normal. The irregularity when phasic has no clinical or pathologic significance.

EXTRASYSTOLES—PREMATURE SYSTOLES—PREMATURE ECTOPIC BEATS— ECTOPIC BEATS—PREMATURE CONTRACTIONS

Extrasystoles are contraction waves which originate at some point in the heart muscle other than the normal sino-auricular node. They may be auricular, in which case the impulse begins in some part of the auricle outside the zone of the sino-auricular node, or they may be nodal, or commonest of all, they may originate at some focus in the ventricle.

Auricular Extrasystole.—Here the impulse originates in auricular muscle outside the sino-auricular node. This results in a premature, or occasional extra beat. Most of the cardiac impulses originate at the usual site and the resulting complexes are perfectly normal. The abnormal beat results in a diphasic or inverted P wave: after this contraction reaches the auriculoventricular node, the impulse follows its normal course. The electrocardiogram then shows most complexes normal, with an occasional extra beat which has a P wave and a normal QRS and T. When the extra auricular impulse occurs at a time when the sino-auricular node is refractory, there is, of course, no diphasic P. An extra P wave may be concealed in the T, splintering elevation, depression, any sudden change in form. When the impulse occurs at a time that the A-V node is refractory, no QRS complex follows the auricular (P) complex. Auricular extrasystoles may be single, multiple, grouped in bigeminal or trigeminal series.

Nodal Extrasystoles.—The impulse arises at the A-V node and travels in both directions—over the auricular musculature in retrograde direction and over the main bundle and branches of the ventricle in regular fashion. Such nodal beats are likely to occur only every four or five regular beats. The electrocardiogram shows the abnormal beat, with the ventricular complex and auricular complex occurring at the same time or near the same time. There is a beat with no P wave preceding the QRS, a normal QRS, with perhaps a P wave inserted between the S and T. The prognosis is not serious though it may lead to paroxysmal nodal tachycardia. Nodal escape is somewhat similar: in the midst of normal rhythm, the S-A node at a certain moment is slow in sending forth the impulse and the A-V node escapes by causing a ventricular contraction. It has no serious prognostic significance.

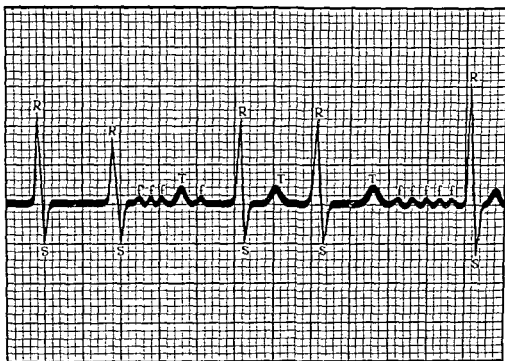
Ventricular Extrasystoles.—These are the commonest of the extrasystoles. The impulse arises apart from the sinus node somewhere in the ventricular muscle, passes in retrograde fashion over the Purkinje muscles to the bundle of His and the A-V node. Such beats may occur singly (once a minute), multiple in runs, or at near regular intervals every second, third, or fourth beats. The electrocardiogram shows the normal beats with a dominant rhythm and when the extra beat is thrown in, a bizarre complex: there appears to be no P wave, to the extrasystole, but there are P waves which may or may not be seen buried in the QRS complex. The QRS takes off soon after the preceding T; it is wide and of large amplitude, often notched with an inverted T following. The succeeding beat follows a full compensatory pause and is usually two full lengths away from the preceding normal beat. The further away the focus of impulse is from the A-V node, the more bizarre the complex. The site of impulse formation may be in the right or left ventricle, and produce characteristic electrocardiographic patterns; left ventricle sites show downward QRS in Lead I, while right ventricle sites show upward QRS deflections in Lead I. (See Castex, Battro, and Gonzalez: *The Diagnosis of the Site of Origin of Ventricular Extrasystoles in Human Beings*, Arch. Int. Med. 67: 76-90, Jan., 1941.) The significance of ventricular extrasystoles is somewhat debatable. They are the common irregularity of middle age and after and are so common that it is hardly possible to ascribe serious prognostic value to all of them. Undoubtedly they represent an irritable myocardium, and such irritants as tobacco, digitalis, and alcohol produce them. In this type, withdrawal of the irritant will cause their cessation. Exercise sufficient to tire the myocardium or wear down irritability will also banish them. The older view was that they were all quite innocent, but of late years in certain cases more significance has been attached to them. They are regarded in some places as indication of destruction of the smaller branches of the coronary arteries, "but do not necessarily mark the patient for a cardiac death." Following acute coronary thrombosis, extrasystoles may make their appearance. On the whole, it is probably safe to say that the significance of an extrasystole depends upon the clinical condition as determined by the history and physical examination.

Auricular Fibrillation.—In auricular fibrillation the dominant rhythm of the auricle is lost entirely. The sino-auricular node entirely relinquishes its function as the pacemaker and impulses begin at other points in the auricular

musculature. The older view was that impulses began in any fiber or in many fibers of the auricular muscle at the same time; the auricle is in a constant state of trembling or fibrillation: impulses that are strong enough to initiate ventricular contraction reach the A-V node at irregular times and at times when the node may or may not be refractory. Another explanation of the functional

AURICULAR FIBRILLATION IRREGULARITY OF THE PULSE

STEP-4



1-ABSENCE OF P-WAVES.

2-IRREGULAR QRS IN TIME AND AMPLITUDE OF DEFLECTION.

(EXCEPT IN A.V. NODE)

3-NUMEROUS SMALL f WAVES

CAN NOT ALWAYS BE IDENTIFIED.

Fig. 126.

disturbance in auricular fibrillation is the circus movement theory popularized by Lewis: this assumes that the irregular contraction wave in the auricle travels in a circular pathway around or outside the sinoauricular node at a very rapid rate, 400 waves or more a minute, and that only when the A-V node is not in a refractory period does it take up the impulse.

The decision as to which of these explanations the clinician should accept is not important from a practical standpoint. Personally I have always felt the

circus movement theory very strained. Probably both types occur. When there are discernible regular *F* waves, there is probably a circus movement. When no waves in the T-Q segment occur at all, the multiple foci of fibrillation mechanism is probably at work.

Clinically, auricular fibrillation is a common and serious form of irregularity invariably leading to some degree of congestive cardiac failure. It occurs most commonly in mitral stenosis, hypertensive or arteriosclerotic hearts, and thyrotoxicosis. It can be distinguished by loss of dominant cardiac rhythm (complete irregularity) and pulse deficit. The therapeutic indication is for digitalis or quinidine.

Electrocardiograms of auricular fibrillation show complete irregularity in occurrence of the QRS complex and absence of the P wave. In place of the P wave or, rather, throughout the S-Q interval, there can often be demonstrated fine waves, called "*f*" waves. When of some amplitude and fairly regular in occurrence, these may represent the circus movement of the auricle. They are best seen in some precordial leads. The QRS complexes may be of different amplitudes.

The condition may be transient or persistent. It sometimes ends spontaneously, in which case there can be seen on successive electrocardiograms first, auricular flutter and then occasional auricular complexes.

In auricular flutter the contraction impulse originates in the auricle outside the sino-auricular node. The theories of multiple ectopic foci and of circus movement have been evoked for it as for fibrillation.

Clinically, flutter may be suspected when the pulse suddenly jumps in multiples—from 72 to 144, or 216, or 288.

Electrocardiograms show usually a regular rapid occurrence of the QRS complex with several large waves in the S-Q segment. The ventricle can respond only to every second, third, or fourth auricular contraction, so there are 2:1, 3:1, and 4:1 ratios. The T waves are often inverted and diphasic, giving a very peculiar appearance to the electrocardiogram. Axis deviation is common as a consideration of the etiology would suggest.

TACHYCARDIAS

Four main forms can be distinguished:

Sinus tachycardia is a rapid regular pulse with the cardiac mechanism intact; the impulse originates at the sino-auricular node, the conduction pathway is intact, and contractility is good, so the P, QRS, and T complexes are all present, the intervals all being shortened. Arbitrarily the definition of sinus tachycardia declares that the rate shall be over 100 per minute. The cause is extrinsic—shock, fever, etc.

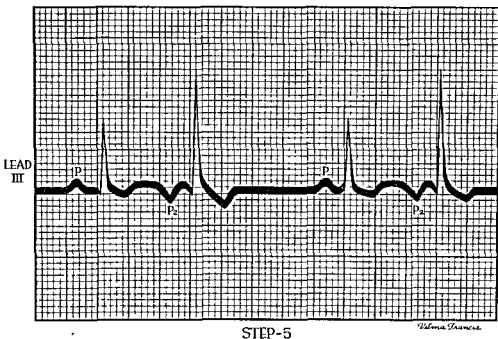
Paroxysmal Tachycardia.—The common form of paroxysmal tachycardia consists in an abrupt onset of very rapid regular heart action. This is auricular paroxysmal tachycardia; the mechanism seems to be a sudden shift of the auricular pacemaker from the sino-auricular node. The electrocardiogram, if the attack is caught at its inception, shows normal complexes with a heart rate of 72, and suddenly a shift to a rate of 160 or 200 a minute. With the onset of this

rapid rate the P waves become diphasic or lost, in which case the P-R interval cannot be measured exactly, the QRS waves are usually not abnormal, the T wave loses voltage, frequently becomes inverted (if not at the onset of the paroxysm, at least soon after).

The inverted T and low take-off of the T from S makes a peculiar looking complex, but careful analysis shows that the QRS is not abnormal—at least in the beginning of an attack. If the attack is prolonged, the QRS may be deformed looking like the complexes of a ventricular tachycardia.

ARRYTHMIAS

AURICULAR EXTRASYSTOLES



NOTE IRREGULARITY OF PULSE

QRS NORMAL BUT IRREGULARLY SPACED AND OF
UNEQUAL AMPLITUDE

AURICULAR EXTRASYSTOLES ARE INVERTED P₂

Fig. 127.

The causes of paroxysmal tachycardia are emotional imbalance, thyrotoxicosis (?), gastrointestinal disturbance, such as cholecystitis, or unknown. Attacks may occur at frequent intervals for years and then cease abruptly. The prognosis is benign.

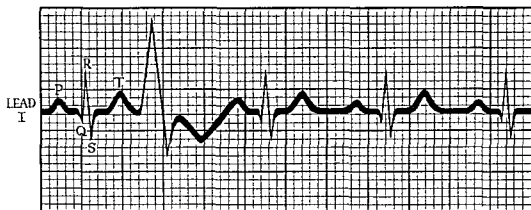
Nodal paroxysmal tachycardia is much the same, except that the pacemaker is shifted to the A-V node. The electrocardiogram is much the same as in auricular paroxysmal tachycardia except that the P wave may be lost by fusion

with the QRS but appears as in premature nodal contractions (not entirely lost). The T wave, unlike in auricular tachycardia, is usually not inverted. The causes and prognosis of this form are no different from those of the auricular form.

IRREGULAR PULSE

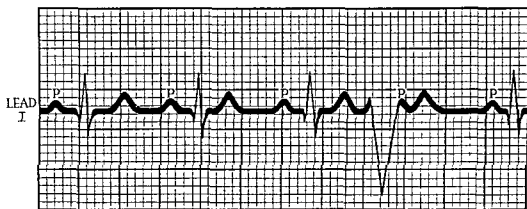
STEP-6

TYPES OF VENTRICULAR PREMATURE SYSTOLES OR EXTRASYSTOLES



VENTRICULAR PREMATURE SYSTOLE
UPWARD DEFLECTION

WIDE QRS-0.12 SECOND — NO PRECEDING P-WAVE



VENTRICULAR PREMATURE SYSTOLE
DOWNWARD DEFLECTION

NO INTERRUPTION OF REGULAR SINUS RHYTHM

P-WAVES COME AT EQUAL INTERVALS

Fig. 123.

Ventricular paroxysmal tachycardia is a succession of rapid, ventricular contractions. The pacemaker has shifted to an irritable focus in the ventricular muscle below the A-V node. The electrocardiogram shows rapid wide QRS complexes of variable form. An alternate upward and downward deflection of QRS is characteristic. The auricular complexes and the T waves usually are lost in

STEP-7

RIGHT VENTRICULAR PREPONDERANCE

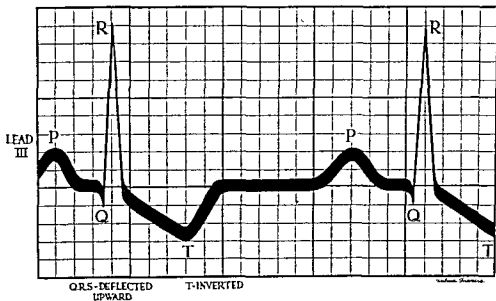
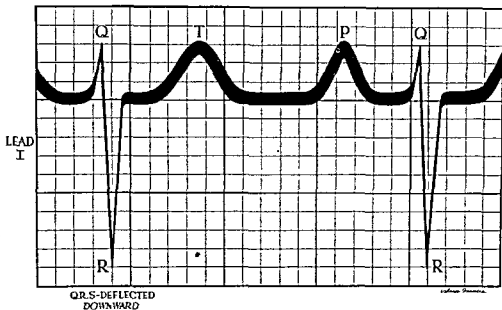


Fig. 129.

the ventricular complexes. The auricles are beating at a slower regular independent rhythm, and P waves may be made out; it is important to attempt to identify them because this is the only way the condition may with certainty be recognized. It occurs more commonly than is supposed; the myocardium is seriously impaired, either by arterial change, infection, or from toxic agents, commonly drugs. The prognosis is serious. Attempts should be made to quiet the heart with quinidine. Digitalis is contraindicated.

STEP-8

LEFT VENTRICULAR PREPONDERANCE

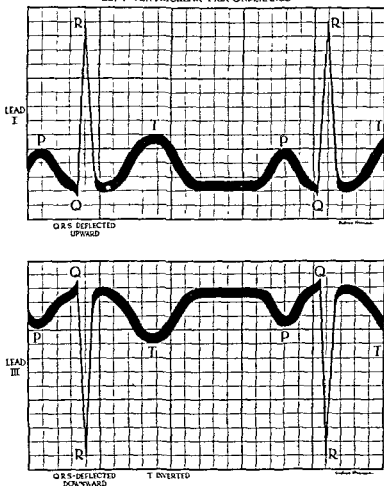


Fig. 110.

Ventricular flutter and ventricular fibrillation are more assumptions than proved clinical entities. They might theoretically follow on ventricular tachycardia.

BRADYCARDIA

Sinus Bradycardia.—The rate is less than 60 per minute, and the cardiac mechanism is intact. The P, QRS, and T waves are all present, with the R-R interval lengthened. The causes are intracranial pressure, sunstroke, hypothyroidism, or jaundice.

Heart Block.—Bradycardia occurs in cases of heart block (A-V block) where the block is at the A-V node or in the bundle of His, and there is a 2:1 or 3:1 ratio, every second or third auricular impulse getting through regularly to the ventricle. The condition may be associated with Stokes-Adams syndrome—syncope or convulsions at moments of cerebral anemia. The cause is

TACHYCARDIA AURICULAR FLUTTER

STEP-9

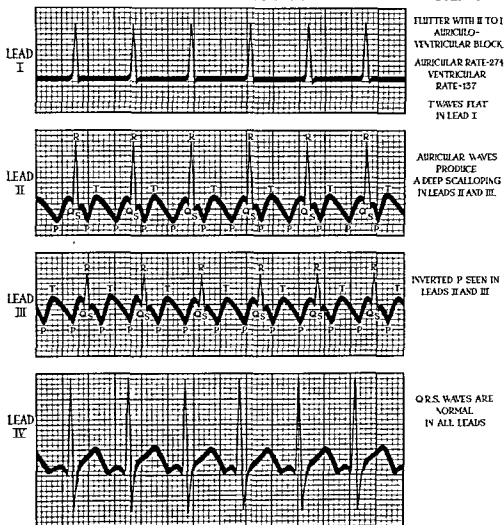


Fig. 131.

Volkmann, Trautman.

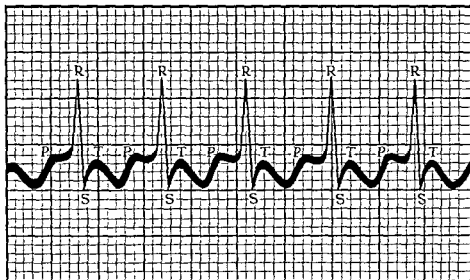
an organic defect of the A-V node or bundle of His due to infection (rheumatism, influenza, syphilis, being the most frequent but, in fact, anything being possible) or arteriosclerotic degeneration, or rarely, a congenital defect. The prognosis is guarded, usually grave (unless caused by administration of digitalis).

The electrocardiogram shows occasional or regular dropped beats. If regular, the QRS complexes are wide apart (6/5 of a second) and two or more P waves appear before the QRS complex. The P-R interval is usually prolonged. When the dropped beats are occasional, such a 2:1 complex appears in the midst of a series of normal complexes.

TACHYCARDIA

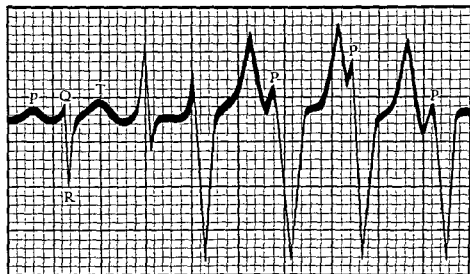
STEP-10

AURICULAR PAROXYSMAL TACHYCARDIA—(THE USUAL TYPE)



Adrian Thomas.

VENTRICULAR PAROXYSMAL TACHYCARDIA—(MORE SERIOUS)



NORMAL
COMPLEX

EXTRASYSTOLES
INITIATING
VENTRICULAR TACHYCARDIA

WIDE VENTRICULAR COMPLEXES
P-WAVES REGULAR BUT NO RELATION
TO VENTRICULAR CONTRACTION

Fig. 132

Other forms of heart block do not necessarily produce bradycardia. Block may occur as:

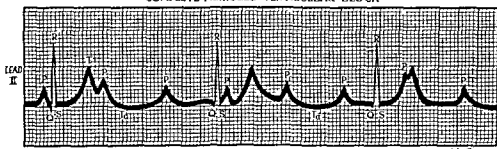
SINUS ARREST.—The sino-auricular pacemaker fails to emit an impulse at the usual time. The electrocardiogram shows a very prolonged complex in the midst of normal complexes. It is a sign of vagus stimulation. It may indicate digitalis action.

INTRA-AURICULAR BLOCK.—Large, broad, or notched P waves indicate intra-auricular block which is a delay of the conduction pathways through the auricular muscle.

PROLONGED A-V CONDUCTION TIME.—This is the beginning, or a mild form, of A-V block.

INTRAVENTRICULAR BLOCK.—Various forms of block occur in the ventricle below the bundle of His.

BRADYCARDIA COMPLETE AURICULO-VENTRICULAR BLOCK



AURICULAR RATE-98 — VENTRICULAR RATE-36

STEP-II

QRS WAVES ARE NORMAL

T-WAVES ARE TALL AND BROAD

P-WAVES FALL IN ALL SORTS OF STRANGE PLACES

P-WAVES ARE FOLLOWED BY A DEPRESSION IN THE BASE LINE.

T_a WAVES OR AURICULAR T-WAVES

Fig. 133.

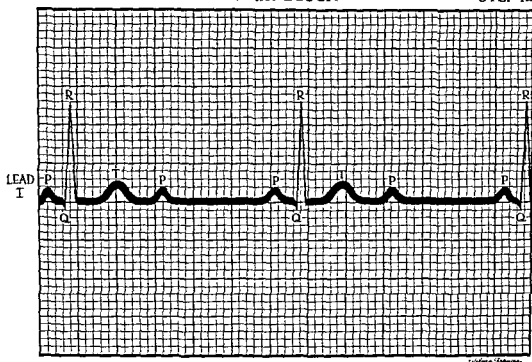
Prolonged QRS is considered as between 0.09 (adults) and 0.12 second. The term embraces some electrocardiograms, formerly classified as arborization block, now best described as defective intraventricular conduction, or, if sufficiently bizarre, as incomplete bundle branch block.

Bundle branch block is block of either the right or left bundles (going either to the right or left ventricles) after they have left the bundle of His. These are usually due to thrombosis or obliteration of the branch of the coronary artery supplying the branch bundle involved. Hypertension, or arteriosclerosis, is practically always present. The condition is, therefore, always serious. The final proof of the condition always rests with the electrocardiogram, but it may be suspected from clinical evidence. There may or may not be a definite history of a cardiac accident, but there is nearly always the history in a person over fifty of a rather sudden onset of bodily fatigue, and shortness of breath.

A characteristic pallor of the face superimposes itself on the previously healthy complexion over a period of weeks. They are the cases we used to call myocarditis. Congestive failure with edema does not necessarily supervene (118 out of 395 cases). (Graybiel and Sprague: *Am. J. M. Sc.* 185: No. 3, March, 1933.) On physical examination gallop rhythm can be detected in 38 per cent of cases (White's figures). Since the two ventricles do not beat simultaneously, there is a difference in the first sounds at the apex and end of the sternum, and King (*Am. Heart J.* 3:505, 1928) has called attention to the "visible apical reduplication," found in 84 per cent of his cases. This "bifid" thrust can be brought out by fastening a straw on the chest over the point of maximum impulse.

BRADYCARDIA HEART BLOCK

STEP-12



PARTIAL AURICULOVENTRICULAR DISSOCIATION BLOCK
2 TO 1 AURICULOVENTRICULAR BLOCK

Fig. 134.

In the electrocardiogram we should expect a wide QRS complex because it takes the impulse longer to get over the blocked pathway. Also a notched QRS complex. And we should expect one ventricle to be preponderant over the other, which is what we do find.

Which bundle—right or left—is blocked as determined by the electrocardiogram, is the subject of a very puzzling historical controversy. In the early days of the electrocardiograph it was supposed on a priori ground, quite naturally,

that the unblocked ventricle would show the preponderance. Under this conception, right bundle block was far commoner than left. But in 1920, F. N. Wilson and G. R. Hermann and their associates, brought forward experimental evidence which changed this entire conception (see Arch. Int. Med. 26: 153,

BRADYCARDIA

AURICULO-VENTRICULAR NODAL RHYTHM

STEP-13

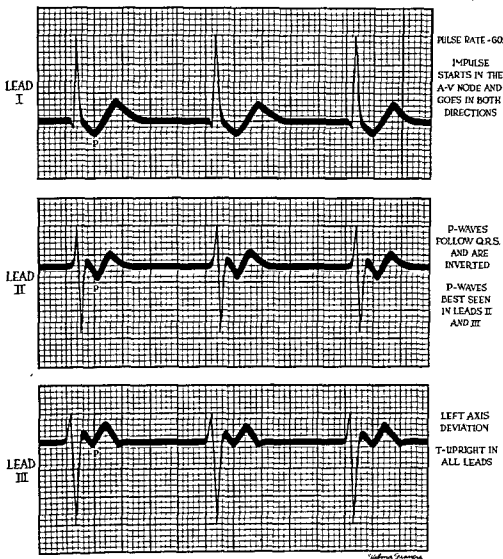


Fig. 133.

1920; Heart 8: 229, 1921; Am. Heart J. 6: 637, 1931) and the new nomenclature rules that with left axis deviation the block is in the right branch. This changes the incidence of damage relatively in the two ventricles, although Wilson and his co-workers subsequently published tracings of two "unusual" types of

right bundle-branch block which, according to Scherf and Boyd, are actually not rare and therefore permit the diagnosis of right bundle branch block with more frequency.

It does not seem logical to suppose that the ventricle with the injury should be preponderant, and all workers are not satisfied in their minds with the new nomenclature. The subject needs more work and more classification. But for the clinician the controversy is not of great consequence.

The signs of left bundle branch block then, as given in approved texts are:

1. Slurring and notching of the QRS waves.
2. Duration of QRS complex of more than 0.12 second.
3. Ventricular complex in Lead I is an upright R spike.
4. The T waves are usually opposite in the main deflection with displacement of the S-T or R-T segment.

Right bundle branch block:

1. QRS waves are notched or slurred.
2. Prolongation of QRS wave beyond 0.12 second.
3. The initial ventricular deflection in Lead I is downward (an S wave) and in Lead III upward (an R wave).
4. T waves usually opposite to the main QRS deflections.

Nodal Rhythm.—James Mackenzie for a long time believed that auricular fibrillation was nodal rhythm—the theory explained the absence of the auricular waves in polygraph and electrocardiograph. The idea was abandoned when Lewis and Cushing independently showed him tracings from dogs in which auricular fibrillation had been experimentally induced and which were identical with clinical tracings in patients. The conception of nodal rhythm suffered something of an eclipse, but it does occur and it has been replaced in the catalogue of electrocardiograph patterns.

In nodal rhythm the A-V node assumes the rôle of pacemaker. The impulse spreads in both directions over the auricles and ventricles. Temporary beats of this kind may occur or rarely it may become permanent. The peculiarity of the electrocardiogram when premature nodal beats occur, is that the auricular and ventricular contractions occur simultaneously; no P wave is formed in front of the QRS, but is located between the S and T waves and is inverted. The QRS is usually normal in contour. The significance of these premature nodal beats is the same as premature beats elsewhere. They may presage the onset of a paroxysmal tachycardia.

Permanent, or rather, continuous, nodal rhythm may be either paroxysmal nodal tachycardia or true nodal rhythm. In paroxysmal nodal tachycardia, the rate is rapid and regular, with the P waves small or confluent with QRS waves and large T waves. It is of benign prognosis. Nodal rhythm is a more permanent phenomenon with a slower rate—50 or 60—with the P waves deformed and may be anywhere before, in the midst of, or behind the QRS; they are often inverted.

Nodal escape is a rare phenomenon in which the sinus node is so slow in initiating stimuli that the A-V node takes over the function. The cause is usually extrinsic (neurogenic) and the prognosis that of the fundamental condition. When the impulse arises lower down the bundle than the A-V node, it is known as ventricular escape.

Parasystole is the condition described when two points contend for the role of pacemaker, such as the sinus node and A-V node, at the same time. The electrocardiograms often look like heart block records. Toxic agents, most commonly digitalis, are the usual cause.

Effect of Drugs on the Electrocardiogram

The electrocardiogram often is the best guide we have to the effect which drugs are producing. When digitalis has produced its full effect and is beginning to be toxic, it may or may not show a slow pulse with extrasystoles, but the electrocardiogram should show effects before this. Quinidine also produces characteristic graphs.

Digitalis.—Digitalis produces a series of changes in electrocardiograms indicating increasing cumulative action. The primary effects of digitalis are to depress conduction and increase irritability of the myocardium. Therefore, the first change is a prolongation of the P-R interval, if a P wave existed before the drug was exhibited. The R-T or S-T segment shows changes next in order. Normally the R-T or S-T segment is an isoelectric line. When digitalis action begins, the R-T segment drops below the base line and assumes a concave appearance about the fourth day, depending on rate of administration. This effect continues until there is a diphasic, or inverted, T wave.

Quinidine is a heart muscle depressant and exercises most of its effects by that action. When given in full doses, it slows the conduction time. The T wave in all leads early becomes iso-electric or inverted and may stay that way for several days after the drug has been discontinued. In fuller doses the P-R interval may be prolonged, and there is slurring, notching, or winding of the QRS complexes. In full toxic dose cardiac standstill and ventricular flutter or fibrillation have been reported. It is a drug whose action should always be watched.

Epinephrine causes sometimes an inversion of the T wave due to lessening of the coronary circulation.

Coronary Artery Disease.—In 1919 Dr. J. B. Herrick, who first called attention to the existence of coronary thrombosis, wrote:

"The thought has been that if it can be proved with a certain artery obstructed there is a definite lesion in the heart muscle or in the conducting system, and if with this lesion there is a definite electrocardiogram, may we not, when we encounter that abnormal electrocardiogram in a human being particularly if he has had the symptoms of coronary thrombosis, be able to state with a reasonable degree of certainty that the patient has had obstruction in a particular portion of the coronary system? May it perhaps be possible to localize a lesion in the coronary system with an accuracy comparable to that with which we locate obstructive lesions in the cerebral arteries?"

This prediction has been completely fulfilled. Indeed, it may be said that in coronary thrombosis the electrocardiogram furnishes us with evidence which

we can obtain in no other way. As was stated, the electrocardiograph taught us the mechanism and the method of differentiation of the arrhythmias, tachycardias, and bradycardias, but in most instances we have been able to absorb this knowledge into the field of physical examination and make the diag-

EFFECT OF DRUGS DIGITALIS INTOXICATION

STEP-14

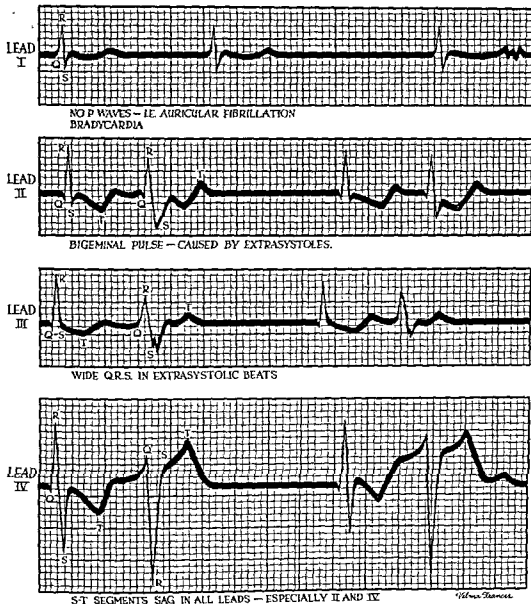


Fig. 136.

nosis of palpation of the pulse and palpation and auscultation of the heart without calling in the services of the electrocardiogram. In coronary thrombosis this is not possible, and the electrocardiogram alone, in the presence of suspicious symptoms, furnishes the criteria by which the final diagnosis is made.

In order to understand the subject fully, knowledge of the anatomy and pathology of the coronary arteries is necessary.

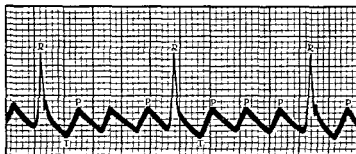
There are two coronary arteries which supply blood to the heart—right and left. The right coronary artery springs from the aorta just inside the anterior cusp of the aortic valve—the anterior sinus of Valsalva. The left coronary artery springs from the aorta just inside the left posterior cusp of the aortic valve—the left posterior sinus of Valsalva.

THE ACTION OF DRUGS

QUINIDINE SULPHATE

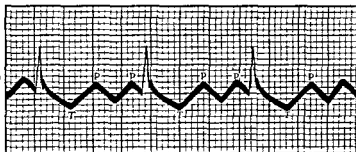
STEP-15

LEAD-II
AURICULAR
FLUTTER



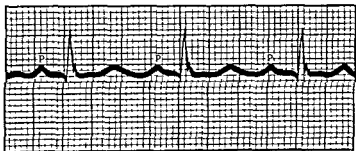
AURICULAR
RATE-280
VENTRICULAR
RATE-70
QRS
SLURRED
SAGGING
ST SEGMENTS

LEAD-II
60 HOURS
AFTER FIRST
ADMINISTRATION
OF QUINIDINE
SULPHATE
5 GRAINS
EVERY
4 HOURS



SLOWER
AURICULAR
RATE

LEAD-II
96 HOURS
LATER.



RESTORATION
OF NORMAL
RHYTHM
PULSE RATE-
75

W. H. France

Fig. 137.

The right coronary artery runs forward between the root of the pulmonary artery and the right auricle to the auriculoventricular sulcus in which it passes to the right, and then turning around the margin of the heart it continues as far as the posterior end of the inferior interventricular sulcus where it ends by dividing

into two terminal branches. In the first part of its course it gives off aortic and pulmonary twigs which supply the roots of the aorta and pulmonary artery respectively, and a right auricular branch which supplies the right auricle.

The left coronary artery takes much the same course, in the opposite direction to the right coronary artery, divides much higher into its two terminal branches. It gives off aortic and pulmonary twigs, supplying the walls of the aortic and pulmonary arteries and left auricular branches which supply the left auricle.

The terminal or ventricular branches of the right coronary artery supply the basal three-fifths of the posterior interventricular septum, two-thirds of the right ventricle and of the adjacent basal, three-fifths of the posterior part of the left ventricle. Branches seldom reach the apex.

The left coronary artery has two main branches. *The anterior descending branch* supplies a third of the anterior part of the right ventricle, the anterior part of the left ventricle, the anterior two-thirds of the basal portion of the interventricular septum, all of the apical portion of the septum, all of the apex of both ventricles and part of the posterior portion of the left ventricle adjacent to the apex. *The circumflex branch* supplies the left third or more (sometimes as much as half) of the posterior part of the left ventricle and about three-fifths of the base of the left ventricle.

Variations in the coronary arteries are, however, very common, not only in different persons but at different age periods. The individual variations are outlined by Gross (*The Blood Supply of the Heart*, New York, 1921, Paul B. Hoeber), Barnes (*Electrocardiographic Patterns*, Springfield, Ill., 1940, Charles C Thomas, Chapter II), and Whitten (*Arch. Int. Med.* 45: No. 1, Jan., 1930). But a careful study of these hardly convinces one that they are of any considerable clinical significance. To quote Barnes:

"So far as the problem of myocardial infarction goes, the most important of these (variations) concerns the blood supply of the posterior aspect of the left ventricle. The most important of the variations has to do with the destruction of the circumflex branch of the left coronary artery on the one hand and of the right coronary on the other: the circumflex branch of the left coronary may extend to supply all of the posterior and basal portion of the left ventricle* including the left interventricular septum. In certain instances† it may extend beyond the posterior interventricular septum to supply a considerable portion of the adjacent right ventricle. The right coronary artery may exceed its usual distribution and reach or go beyond the obtuse margin of the left ventricle as well as supplying the apex of the ventricles.‡

"These anomalies may play a tragic role in the outcome of acute coronary occlusion. Occlusion of one of these vessels supplying an abnormally large portion of the left ventricle results in a large infarct from which the patient seldom recovers. Such a patient is the victim of a caprice of nature by which she endowed him with an abnormal blood supply." (*Electrocardiographic Patterns*, p. 9.)

*Four per cent of cases, according to Campbell (Quain's Anatomy, Longmans, Green & Co.).

†Eight per cent of cases, according to Campbell (Quain's Anatomy, Longmans, Green & Co.).

‡Twenty per cent of all cases, according to Campbell (Quain's Anatomy, Longmans, Green & Co.).

The age variations consist first in a gradual diminution of the entire blood supply of the heart, beginning really at the age of thirty. There is a decided tendency for the blood supply of the right ventricle to be more rapidly diminished than the left. The integrity of the blood supply to the right ventricle is to a considerable extent the determining factor in longevity. As Gross says, "A man is as old as his right coronary artery."

Sudden obstruction of a coronary artery branch of any size results in an anemic infarct and myomalacia of the heart muscle. The changes in the electrocardiogram following sudden obstruction do not depend upon what artery is involved but on what part of the heart muscle is destroyed.

Are the coronary arteries end arteries? Cohnheim long ago declared they were, and this stood as a dogma from his day until about 1907 when Spalteholz, as a result of injection experiments, announced that (1) *no end arteries exist* in the heart, (2) rich anastomoses occur in all layers of the heart and through the vasa vasorum in the great vessels.

This view was supported by the work of Gross, Campbell, Smith and others and by Herriek's clinical observations (J. A. M. A. 59: 1912) that there was a group of patients with coronary thrombosis who survived the obliteration of a major vessel for some time. There is a considerable body of data, however, that cannot be explained in quite so cavalier a fashion. Sudden obstruction of a good-sized branch of coronary artery results in an anemic infarct with almost complete destruction of tissue. True, in many of these cases, healing occurs, which would indicate that the capillary circulation at least is anastomotic.

To quote Wiggers (in Levy: *Diseases of the Coronary Arteries*, New York, 1936, The Macmillan Company):

"From a pathologic standpoint it has long been accepted that the coronaries are terminal arteries, for when plugged by emboli or thrombi in man or when artificially occluded in animals, an infarct results. The rapid necrosis of cardiac tissue could scarcely occur, were adequate anastomoses present."

And W. T. Porter (*An American Text Book of Physiology*, W. B. Saunders, 1901) stated:

"The objection that one of the coronary arteries can be injected from another, and that therefore they are not terminal, is based on the incorrect premise that terminal arteries cannot thus be injected and has no weight against the positive evidence of the complete failure of nutrition following closure. The passage of fine injection-masses from one vascular area to another proves nothing concerning the possibility of one area receiving its blood supply from the other. Such supply is impossible if the resistance of the communicating vessels is greater than the blood pressure in the smallest branches of the artery through which the supply must come."

The question is stated very well by Blumgart, Schlesinger, and Davis (*Studies on the Relation of the Clinical Manifestations of Angina Pectoris, Coronary Thrombosis and Myocardial Infarction to the Pathologic Findings*,

with Particular Reference to the Significance of the Collateral Circulation, Am. Heart J. 19: No. 1, Jan., 1940):

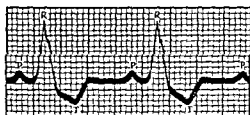
"The injection of a lead-agar mass rarely revealed any evidence of an anastomotic connection between the left and right coronary arteries. The viscosity of the lead-agar mass is approximately three times that of blood, and regularly penetrates to arterioles forty micra in diameter. . . . When, however, in such normal hearts red colored *watery* solutions were injected into the right coronary artery, some of the material could be visualized in the branches of the left coronary artery. Conversely when blue colored *watery* solutions were injected into

BUNDLE BRANCH BLOCK

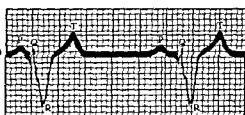
LEFT BUNDLE BLOCK

STEP-16

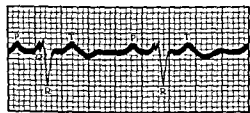
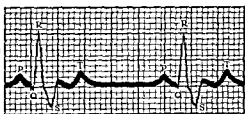
RIGHT BUNDLE BLOCK



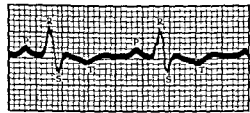
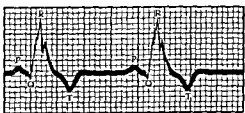
LEAD I



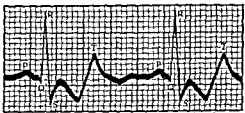
LEAD II



LEAD III



LEAD IV



WIDE QRS.—015 SECONDS
LEFT AXIS DEVIATION FORM.
INVERTED T IN LEAD I.
S-T SEGMENT CONVEX WITH A LATE
DIP IN LEAD III.

WIDE QRS.—018 SECONDS
RIGHT AXIS DEVIATION FORM
T UPRIGHT IN LEAD I.
T INVERTED IN LEAD III
T DIPHASIC IN LEAD II AND IV

Fig. 133.

the left coronary artery, some of the injected solution was always found in the branches of the right coronary artery."

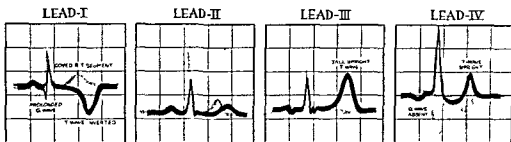
"In summary," they write in the article, "it may be stated that regardless of the age of the subject, normal hearts in which there is little or no coronary arteriosclerosis regularly have fine inter-coronary communications but do not possess an anastomotic circulation through vessels large enough to be functionally significant in obviating the untoward results of rapidly developing coronary narrowing or occlusion."

STEP-17

NORMAL  ABNORMAL 

HEALING ACUTE ANTERIOR INFARCTION

LATE Q₁ T₁ PATTERN



HEALING ACUTE POSTERIOR INFARCTION

LATE Q₃ T₃ PATTERN

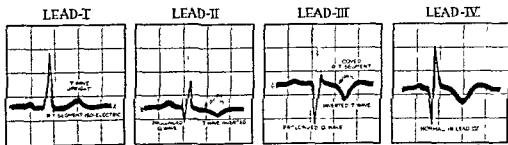


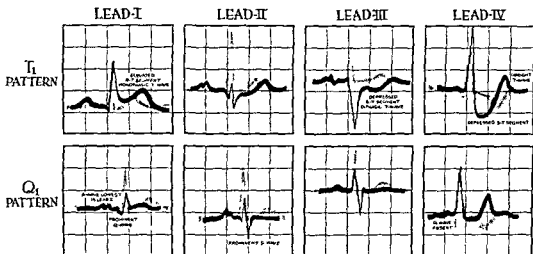
Fig. 139.

Of course, there are variations in which the coronary arteries may show instances of true anastomoses. Most students believe that in young hearts capillary anastomosis alone is the rule. Herrick thought that with *gradual* obliteration as age advances, there was often established a precapillary anastomosis. Gradual obliteration, then, is an advantage if thrombosis or obliteration occur later in life.

The outcome of a coronary occlusion depends, therefore, on many factors, physiologic, anatomic and developmental (involutionary) over which neither

STEP-18

ACUTE ANTERIOR INFARCTION OF LEFT VENTRICLE

NORMAL  ABNORMAL 

ACUTE POSTERIOR INFARCTION OF LEFT VENTRICLE

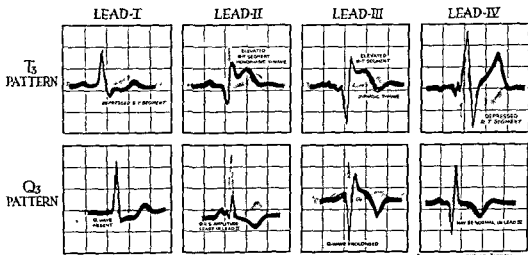


Fig. 140.

the patient and his habits of life nor the physician and his therapeutics has any control. Sudden occlusion of a main artery almost invariably results in death. Sometimes in embolism, obstruction occurs so rapidly that death occurs before infarction can take place. If the occlusion develops gradually, as in advanced arterial degeneration or atheroma, there is likely to be more or less fatty degeneration, with a patchy fibrosis and perhaps dilatation of the ventricles.

Naturally, because of the anatomic arrangement, thrombosis occurs in one of the branches of the left coronary artery more often than in the right. That is to say, because the left coronary artery branches sooner into the smaller divisions, thrombosis is more likely to occur there. The artery most frequently affected is the anterior descending branch of the left. Over 90 per cent of infarctions occur in the left ventricle either on the anterior portion in posterior aspect near the base or in the interventricular septum.

The changes in the electrocardiogram which have been proved by most careful post-mortem records are now quite generally agreed upon. There is some slight confusion in the accounts of different writers, mostly in nomenclature and a desire to adhere to personal verbal designations. Also, the clinician should remember that, as Wilson and his co-workers emphasized, in any single electrocardiogram, one or more of the characters may be absent or poorly developed.

The following patterns are characteristic:

1. Acute infarction of the anterior wall of the left ventricle— Q_1T_1 pattern.
 Q_1 element.

"A conspicuous and in most instances rather broad Q in Lead I, the absence of Q in Leads II and III; the small amplitude of the largest initial deflections in Lead I and the presence of a conspicuous S in Leads II and III." (Wilson et al.: *Hcart* 16: 155-199, June, 1933.)

T_1 Element.—Elevation of the R-S-T segments in Lead I and depressed in Lead III. "The characteristic feature of the T_1 type of electrocardiogram consists of an elevation of the R-T segment in Lead I. This change may occur almost immediately after an attack of acute ventricular infarction. The R-T segment arises on the descending limit of the R wave before it has returned to the base line." (Barnes: *Electrocardiographic Patterns*, Charles C Thomas, 1940.) The S-T segment in Lead III is depressed and ends in a positive (upright) T wave. As healing occurs, the T wave in Lead I becomes sharply inverted and the R-T segment tends to return to the normal.

Lead II.—Absence of Q wave and depression of R-T segment. In the course of a few days the T_1 is depressed, but the absence of the Q_1 is permanent.

2. Acute infarction of the posterior wall— Q_3T_3 pattern:

Q wave absent in Lead I. A large Q wave in Lead III and conspicuous Q wave in Lead II.

In recent infarction elevation of the R-T segment in Lead III; S-T segment is depressed in Lead I.

During healing the R-T segments tend to return gradually to the isoelectric level and there is a progressive change in T_3 which becomes inverted. T_1 may also become inverted.

"The R-T₂ segment arises from the descending limb of the R wave like a plateau and often with a slightly convex elevation, and then gradually descends to the base line at a point where a negative T wave may subsequently appear." (Barnes, *vide supra*.)

In Lead IV the normal Q wave appears, but the T is exaggerated. Early after an attack the R-T interval is elevated, but later marked inversion of T₂ may occur. Splintering and widening of the QRS complexes and A-V block may also appear in electrocardiograms of myocardial infarction. Auricular flutter and auricular fibrillation may appear as complications.

Mixed patterns may occur, due to infarction of both the anterior and posterior wall of the left ventricle, to variation in the coronary arteries, or to the influence of scar tissue from an old infarct in conjunction with a fresh infarct.

The evidences of healing are obviously quite as important and valuable to the clinician as the evidence of the actual infarction. They have been indicated above. In summary they are:

Anterior Wall Infarctions.—The R-T segment undergoes gradual changes; the depression becomes less and less, but the take-off retains a curved form with the convexity upward. The T wave gradually becomes inverted. In Lead III just the opposite occurs, the T wave becomes upright and gradually attains a striking size. The R-T segment eventually may become entirely normal in all leads, but Lead I may show a Q wave which will persist for years. This may suggest a past infarction even when the T wave is normal. The R wave in Lead IV will remain permanently absent.

Posterior Infarction—Q₃T₃ Pattern.—The changes indicating healing in Lead III are gradual return of the R-T segment to normal, deep inversion of R and persistence of Q and inversion of T in Lead IV.

Barnes believes that too much emphasis is put on Lead IV changes and feels that clinicians should study the standard leads as of primary importance in the diagnosis of myocardial infarction. The extraordinary claims made for the superiority of the fourth lead arrive from lack of recognition and failure to grasp the equal significance of the changes in the standard lead. This is sage advice although there is no reason why the clinician should not give weight to all the evidence he has and need not "take sides" whether with the standard leads or with Lead IV.

Other Electrocardiographic Patterns.—Barnes (*vide supra*) has pointed out certain patterns which he believes indicate (1) predominant ventricular strain—left and right and, (2) pericarditis. They are:

1. **LEFT VENTRICULAR STRAIN.**—Inversion of T wave in Lead I and Lead II, a depression of the S-T segment in Leads I and II and frequent elevation of S-T in Lead III, and, of course, left axis deviation. They are naturally particularly associated with hypertension. The action is reversible and the electrocardiograms return to normal when the strain is released. An *atypical* form is an electrocardiogram without left axis deviation, negative T waves in Lead I and slight depression of the S-T segments. Such atypical tracings are considered to indicate a poorer prognosis than the typical ones.

2. **RIGHT VENTRICULAR STRAIN.**—McGinn and White (J. A. M. A. 104: 1473, April 27, 1935) furnished electrocardiograms which they considered typical of pulmonary embolism. Barnes had independently arrived at the same conclusion. He, however, went further and associated this pattern with acute right ventricular strain (acute cor pulmonale).

"The S wave in Lead I is usually prominent, though this feature may be lacking in some tracings. There is seldom a Q present, conspicuous or otherwise. The T wave in Lead II is sometimes inverted, but usually of low voltage. If serial tracings are taken after pulmonary embolism, an upright T_2 of normal voltage may be observed to change to one of low voltage, or it may become isoelectric. If, at the same time a positive T_3 is converted into a negative T_3 , these changes alone have considerable weight in suggesting the occurrence of pulmonary embolism particularly if the effect of digitalis therapy can be excluded." (Barnes op. cit.)

These changes, it will be seen, are most likely to be confused with electrocardiograms taken immediately, or shortly after, an infarction of the posterior and basal portions of the left ventricle. If so, in differential diagnosis the evidence of the electrocardiogram is important (though hardly, I should say, competitive with physical signs). Barnes outlines the differences as follows:

1. "In acute infarction of the posterior and basal portion of the left ventricle, S_1 may be present but tends to be smaller than in pulmonary embolism. Moreover, S-T depression in Lead I is more marked and more constantly observed following acute posterior infarction.

2. "The R-T segment in Lead II usually is definitely elevated in acute posterior infarction and, if that is not true, T_2 is inverted with a contour either typical of or approximating the cove plane T wave.

3. "The elevation of the R-T segment in Lead III in posterior left ventricular infarction usually is much greater than that observed in pulmonary embolism.

4. "The R-T segment in Lead IV is depressed frequently if a tracing is taken shortly after an acute posterior basal infarction.

5. "The R wave in Lead IV is seldom diminished following acute posterior infarction of the left ventricle but on the contrary tends to be large."

The electrocardiographic pattern of acute right ventricular strain is shown by pathologic evidence to be associated with extreme dilatation of the right ventricle. The suggestion is that this is due to insufficiency of the coronary arteries. Since the literature (as well as my cardiologic colleagues' records) presents a blank under the heading of right ventricular infarction, the hint is obvious that if ever such records are associated with autopsy findings of right ventricular infarction, they will resemble the electrocardiograms of acute right ventricular strain.

3. **CHRONIC RIGHT VENTRICULAR STRAIN.**—The S_1 wave is very prominent and prolonged. There is a tall R_3 (right axis deviation); $S-T_1$ is elevated slightly; T_1 is positive of low voltage; T_2 is usually inverted; Q_1 is present, often exaggerated.

Chapter 28

BASAL METABOLISM

"For every species of animal there is a typical minimum of necessary metabolism which is apparent in experiments when no food is given."

Thus two German investigators (Bidder and Schmidt), working in Russia in the middle of the nineteenth century gave a clear conception of what is meant by basal metabolism. As long ago as 1893, Friedrich von Müller discovered the high metabolism of exophthalmic goiter by noting the large nitrogen losses in patients who were receiving enough food to maintain a normal person in nutritive balance. In modern clinical practice the standard of basal metabolism is measured by the oxygen consumption in a given period of time in an individual at rest compared to the ideal norm of an individual of that age, weight, height, and/or body surface.

The first determinations were made in large respiration calorimeters. To-day, in the United States at least, the small portable respiration apparatus is used extensively in hospitals and offices, and according to careful comparative tests are within ordinary clinical limits of requirement, as accurate as the larger apparatus. The portable apparatus is constructed so that a close-fitting, non-leaking mouthpiece with nose clips shutting off leakage from the nose assures that all respired air shall go in and out of the oxygen tank. The expired air passes through a container in which there are loosely packed lumps and crystals of soda lime (caustic soda and hydrated lime mixed with water, then hardened, dried, ground, screened, and moistened) which removes the carbon dioxide.

The procedure:

1. Order the patient to eat a light supper the night before the test.
2. No breakfast except a glass of water in the morning.
3. All bodily activities should be reduced to the minimum between waking and making the test.
4. Record temperature and barometric pressure in room where the test is being conducted.
5. The apparatus, mouthpiece, and nosepiece are adjusted, and the patient, in a recumbent position, breathes quietly for ten to fifteen minutes.
6. The amount of oxygen consumed is measured.
7. The square meter of body surface of the patient is measured. The height and weight are used to determine this, but it is not the height and weight but actually the surface area which determines the standard metabolism. Heat production is the same per square meter of body surface though it differs greatly per kilogram of body weight. Lusk wrote: "Turner came to a better understanding regarding the law of surface area. He found that two guinea pigs of

different sizes had the same heat production per square meter of surface even though they lived surrounded by an air temperature of thirty degrees Centigrade, thus excluding all thermal influences."

8. Calculations are made and the actual amount of oxygen consumed by the patient is compared with the ideal for an individual with the same surface area

The results are given to the clinician as 0 or plus 1 (and on up) or -1 (and on down), as the case may be.

The clinician himself need not conduct this examination, provided the test is conducted by an experienced and intelligent technician and the results furnished him are reliable. Every clinician, however, should have had at least one test conducted on himself and have been present at a carefully conducted test on one or two of his patients.

The value of a basal metabolism determination is in direct proportion to the precautions which are taken to make it accurate. It is a quantitative test and therefore not one where slipshod and careless methods have any place. To allow the patient to sleep at home, arise and come downtown to the doctor's office and take the test may be all right for a preliminary trial, but for really reliable information, he should spend the night in a hospital and have the test made while still in bed. The longer the period over which the test is conducted, the better. Every such consideration seems to me of major importance in this field.

Physiology of Basal Metabolism.—The metabolism thus recorded was called by Magnus-Levy "Grundusatz." It is not the lowest metabolism that can be obtained, since lower figures can be obtained after prolonged undernutrition or perhaps during profound sleep. For this reason Krogh suggested the term "standard metabolism"; it never, however, came into general use. Benedict called it "postabsorptive" to denote the fact that it is made after the absorption of food has ceased. But Plummer and Boothby's name "basal metabolism" caught on and has stuck.

Life cannot be maintained without the production of heat even in cold-blooded animals. The human body constantly loses heat to the surrounding air, in spite of the fact that the skin and subcutaneous fat are exceedingly poor conductors. Cadavers cool at the rate of 0.4 degree to 0.8 degree Centigrade per hour. The constant activities of vital organs keep the body temperature up even at complete rest. Loewy estimated that heart action accounts for 3.6 per cent of metabolism and respiratory movements for 10 per cent. Krogh thought the kidneys accounted for 5 per cent of the whole and that the various involuntary activities of the various organs could account for 25 per cent of all metabolism. The tone of the skeletal muscles is responsible for a large part of the basal metabolism.

Most determinations of basal metabolism have been conducted on a very useful experimental animal—young men in laboratories. Our standards are based then, on human material, and taking large groups of normal men or women of the same age and size, basal metabolism readings, conducted under favorable conditions, fall within 10 per cent of the average.

Age and sex play some part in determining basal metabolism. In premature infants heat production is extremely low, and gradually increases, especially as muscular activity increases. There are many studies of the metabolism of the newborn infant (at term). It is lower than that of the adult and much lower than that of older infants and children. The average metabolism of boys at puberty is 25 per cent above the adult level. This was determined by DuBois in a group of Boy Scouts. Two years later the same boys showed an 11 per cent above the adult level. In old people the basal metabolism is low, but we have no very good figures. One inmate of the New York Home for the Aged and Infirm, studied by DuBois, showed a metabolism of 21 per cent below the average adult of his surface area. But this probably is extreme. *In summary, the basal metabolism is low at birth, rises sharply in infancy, rises further at puberty, falls to a lower level from seventeen to fifty, and then begins to fall gradually.*

In general, males have a higher basal metabolic rate than females. Benedict and Eames compared large groups of men and women in the prime of life and found the women on the average five to 6 per cent lower. The difference is probably due to higher muscular tone in men.

Race seems to have little influence, although comprehensive studies are not available. Almeida made a study of white men and Negroes in Brazil and found the Negroes had a basal metabolism 8 per cent higher than the whites. This is explained by the sedentary life of the whites. Most of those studied were physicians who succumbed to the climate and took little exercise. One of them undertook systematic athletics for a time and his metabolism rose.

Athletes, studied by Benedict and Smith (*J. Biol. Chem.* 20: 243, 1915), averaged 6 to 7 per cent higher than nonathletes.

No difference was observed between vegetarians and nonvegetarians.

Limits of Normal

The clinician may disregard readings of 10 per cent either plus or minus as within the limits of normal variation. This refers more particularly to a first or diagnostic reading. When comparative readings are made to indicate improvement or the reverse under therapeutic management, this standard may be relaxed. In point of fact, it is doubtful if 10 per cent is enough leeway. "It seems better to adopt \pm fifteen per cent as the range for normals and miscellaneous controls rather than \pm ten per cent." (Barach and Draper: *J. A. M. A.* 84: No. 10, March 7, 1925.)

Basal Metabolism in Disease.—The only conditions in which basal metabolism determinations are of any clinical value are those in which disturbance of the function of the thyroid gland is suspected. But since this includes all patients who have borderline psychoneurotic symptoms, and all middle-aged persons, male and female, who have menopause symptoms which might be due to hypothyroidism, the actual number of patients in which it is useful is very large.

The syndromes of many "nervous" patients are strikingly similar to the symptoms of hyperthyroidism, and, indeed it is possible that in many instances the psychoneurotic state may be partially due to excessive thyroid secretion.

McCaskey (J. A. M. A. 74: No. 14, April 3, 1920) listed the following symptoms which suggest investigation of basal metabolism readings:

1. Psychoneurotic disturbances.
2. Circulatory disturbances.
 - (a) Tachycardia or bradycardia.
 - (b) Cardiac myasthenia
 - (c) Arrhythmias.
3. Fine tremors.
4. Hyperhidrosis and hypohidrosis.
5. General debility.
6. Loss of weight.
7. Slight temperature disturbances.

Of 2,569 patients with exophthalmic goiter, Boothby and Sandiford (J. Biol. Chem. 54: 783, 1922) found that 93 per cent had a basal metabolism above 20 per cent, whereas in 2,417 patients with conditions not due to thyroid disturbance, 3.1 per cent had a rate above 20 per cent. Of the latter, endocarditis, Hodgkin's disease, malignancy, encephalitis, secondary anemia, and leucemia accounted for most cases.

Recurrent exophthalmic goiter showed 90 per cent above 20 per cent.

Adenoma of the thyroid (1,425 cases) showed 68 per cent above 20 per cent.

Colloid goiter showed 3 per cent between 20 per cent and 16 per cent plus.

Myxedema showed 80 per cent at or below 20 per cent minus.

Cretinism showed 47 per cent at or below 20 per cent minus.

Malignancy of the thyroid showed 22 per cent above 20 per cent and 2 per cent below 20 per cent.

Means and Aub (J. A. M. A. 69: 33, 1917; Arch. Int. Med. 24: 404 and 645, 1919) drew the following conclusions:

1. "Patients with an outspoken clinical picture of hyperthyroidism invariably show increased metabolism, and those with definite clinical pictures of hypothyroidism invariably show decreased metabolism. Those with goiters, but no signs or symptoms of abnormal thyroid function, for the most part show normal metabolism.

2. "Patients with atypical or incomplete clinical evidence of abnormal thyroid function may show normal or abnormal metabolism. The majority show normal metabolism.

3. "By inference from the indirect evidence we believe that in these borderline thyroid cases, provided that in the first place a true basal rate is secured, and, provided that certain well-recognized causes for increased metabolism, such as fever, acromegaly, leucemia, and severe anemia are excluded, the finding of an increased basal metabolic rate is strong presumptive evidence of hyperthyroidism. In a similar way, provided that such conditions as starvation, hypopituitarism, and hyposuprarenalism are excluded, a low metabolic rate is strong presumptive evidence of hypothyroidism.

4. "To that extent, then, the metabolism test is distinctly useful in differential diagnosis. Like all other laboratory tests it should only be interpreted with due regard to all other clinical and laboratory findings, and with due regard for its limitations and pitfalls."

The basal metabolic rate is a good index of the progress of treatment in thyroid disease. In myxedema and cretinism if the patients can tolerate thyroid extract, the basal metabolic rate invariably rises under its use.

In hyperthyroidism, with rest alone, Kessel, Lieb, and Hyman (Arch. Int. Med. 31: 433, 1923), found that 82 per cent of their patients returned to their economic and social activities and had a basal metabolic rate below +18.

Two-thirds of the patients with exophthalmic goiter who were treated with x-ray had a substantial reduction of the basal metabolic rate. With the administration of iodine in exophthalmic goiter, the basal metabolic rate falls rapidly, usually to normal within a few days, but this level is not maintained, even when the iodine is continued.

After thyroidectomy, the basal metabolic rate falls rapidly. Boothby's cases show an average fall from +60 per cent before operation to +20 per cent after operation.

Other Endocrine Disorders.—

Pituitary—Acromegaly.—In thirty cases Boothby and Sandiford (J. Biol. Chem. 54: 783, 1922) found the majority within 15 per cent of normal, one below normal, and eight more than 20 per cent above normal.

Simmond's Disease.—The basal metabolic rate is likely to fall lower than in any other condition except hypothyroidism (–30 to –40 per cent).

Fröhlich's Syndrome.—Generally normal and only occasionally low.

Adrenals—Addison's Disease.—The basal metabolic rate in Addison's disease is moderately depressed from –15 per cent to –20 per cent and is coincident with the state of nutrition.

Sex Glands.—No characteristic changes.

Obesity.—A meal consisting of 200 grams of chopped meat, 50 grams of fat, 200 grams of bread and one-half liter of coffee in nineteen normal subjects caused a rise in metabolism of 24 to 52 per cent; in constitutionally obese individuals the rise after the same meal was from 4 to 29 per cent (Plaut: Deutsch. Arch. Klin. Med. 139: 285, 1922).

Diabetes.—In mild cases there is no change from the normal. In severe untreated cases there is undernutrition and a low basal metabolic rate (in extreme cases –30 to –40 per cent). In coma a patient showed a basal metabolic rate of +11 per cent.

Fever.—The basal metabolic rate is universally increased in fever, 20 to 36 per cent on the average. (Graefe: München. med. Wchnschr. 67: 1081, 1920.) The increase is not specific or selective for any particular fever.

Arthritis.—Eighty per cent of cases showed a metabolism within normal limits. Twenty per cent were slightly below normal, the lowest figure being –21 per cent. (Pemberton and Tompkins: Arch. Int. Med. 25: 24, 1920.)

Drugs.—Caffeine increases metabolism 3 to 10 per cent. Alcohol in the amount of 30 to 45 c.c. causes no rise. Antipyretics cause a slight fall. Quinine causes no appreciable fall even in exophthalmic goiter. Potassium iodide causes no fall. (See review of the subject by Boothby and Rowntree: J. Pharmacol. & Exper. Therap. 22: 99, 1923.)

Chapter 29

OPHTHALMOSCOPY, OTOSCOPY, AND LARYNGOSCOPY

*"A little learning is a dangerous thing;
Drink deep, or taste not the Pierian spring"*

Nowhere in the field of learning is Pope's couplet more applicable than to the internist who decides to examine the retina, the eardrum, or the larynx. For a long time internists were solemnly admonished that they must be experts in these departments. Rosy promises of how much such examinations would add to their knowledge of their patient's condition. On both counts experience has taught me to be quite skeptical.

Under the influence of the admonitions above referred to, I have registered at large special hospitals and taken intensive courses in ophthalmoscopy, otoscopy, and laryngoscopy and can perform a creditable set of maneuvers in making these examinations; but as for my judgment in a doubtful or borderline condition of any of these organs, I would certainly call in consultation a practicing oculist, otologist, or laryngologist. Nor do I know any internist and very few neurologists or pediatricians in whose judgment in these matters I have any more confidence than I have in my own.

As to what these examinations contribute to a diagnostic problem, it is pleasant to hear the persuasive voices in the affirmative, but even while they are ringing in my ear, cold experience whispers that in most instances they contribute nothing. In a doubtful case of brain tumor the finding of a papilledema of two diopters, yes. In a child with a fever, indications of pus behind the eardrum, yes. In a mysterious case of failing nutrition, a subglottic laryngeal tumor, yes. But mostly, no. We are intrigued by the knowledge that in a case of arteriosclerosis, nephritis, or diabetes, the only place in the body where we can actually see the arterioles, as it were naked, is in the retina. But if the internist cannot construct from the information he gets from his sphygmomanometer and his urine glass, what the condition of the arterioles is, he must have very little imagination.

The accounts which follow cannot be expected, in the light of the above declarations, to be either complete, or, except as they reflect the experience of nearly half a century among the beasts of Ephesian diagnostic problems (First Corinthians 15: 32), instructive.

THE RETINA

The ophthalmoscopic examination should be systematic, noting in turn: (1) the color or reflex of the retina; (2) identification of disc, noting form, color, margins, differences of level and vessels; (3) the macula.

1. The pigment epithelium of the retina is dense enough that no details of the choroid beneath it can be perceived. Its color is red in members of the white

race, gray in the Negro, bright red in the albino. Darker pigment rings surround the disc and macula. The color of the retina and the light reflex is dark gray, or even chocolate, in the Negro, and very light pinkish in the albino. "The aspect of the fundus of the young eye differs as much from that of the adult as the countenances, and bears all the peculiar look of freshness which youth possesses." (Loring: *Textbook of Ophthalmoscopy*, 1886.)

2. The disc (or papilla, or optic nerve) is vertically oval with sharply defined edges and clearly outlined scleral and pigment rings, and a shallow excavation in the center at the point of emergence of the vessels. Its color is brighter on the temporal than on the nasal side. The vessels are clearly distinguishable from each other: the arteries are narrow and brighter and have a distinct light streak; the veins are larger, darker, and without a light streak. There is considerable variation in their branches and distribution.

Differences in level of the disc, especially the amount of choking in diopters, are difficult for the average nonspecialized diagnostician to learn accurately.

3. The macula appears darker in color than the rest of the fundus with a light reddish area in the center.

Pathologic Retina

The diseases of the retina which are of interest to the general internist are relatively few, but the number of patients whom he may examine in this way are many. Thus the physician who sees a number of middle aged patients with arteriosclerosis, hypertension, nephritis, or diabetes will examine the retina frequently as will the neurologist and syphilologist.

To list the diseases which mark the retina they are: syphilis, arteriosclerosis, nephritis, diabetes, toxemia of pregnancy, and brain tumors. Rarer conditions are tuberculosis (meaning it rarely affects the retina) multiple sclerosis, embolism of the retinal artery (usually from mitral stenosis) melanoma, and leucemia. The occurrence of cysticercus parasites is of theoretical but not practical interest.

Syphilis of the Retina

Chorioretinitis, usually called *choroiditis*, is a late secondary manifestation of acquired syphilis. In pre-Wassermann days all cases of *choroiditis* were treated with mercurial inunctions, but since then it is recognized that focal infection and arteriosclerosis can produce changes hardly distinguishable from the specific type. It is common in congenital syphilis. *Chorioretinitis* goes through a progressive process and may be seen and detected in any stage. First there is an exudate from the choroidal vessels with leucocytic infiltration; this inevitably extends, to a certain extent, to the retina so that at this time the ophthalmoscopic appearance is that of a gray haze over the retinal image which hides all details of the choroid entirely. With the progress of the inflammation the *lamina vitrea* is thinned or destroyed at least in spots, and the choroid shows through. Since the vessels can be seen, especially the choroidal chromatophore cells, the ophthalmoscopic picture is that of a reticulated surface of black spots alternating with red areas.

Syphilitic arteritis with whitish streaks of exudate along the vessels is a less common manifestation, and thrombosis of a retinal vein is quite rare.

Changes in the *optic nerve* are quite common in early acquired syphilis. A Cooperative Clinical Group found in a systematic examination of 3,244 patients with early syphilis, some change in the nerve in 11.1 per cent. Severe inflammation with impairment of vision occurs in only a small number. The clinical pictures of optic neuritis is haziness or obliteration of the normal retinal outlines, blurring or loss of the physiologic cup, edema and elevation of the nerve head. The inflammation may spread from the nerve head to the retina, giving the picture of neuroretinitis. The degree of visual failure is variable. The prognosis is usually good.

The most frequent and characteristic retinal change in *late syphilis* is optic nerve atrophy. It is a part of generalized neurosyphilis. It occurs in 10 to 15 per cent of acquired neurosyphilis (tabes and taboparesis) and as high as 50 per cent in congenital syphilis. The ophthalmoscopic changes are those of a gradually developing bluish-white pallor of the nerve head, until it finally appears as a dead china white. There are no associated retinal or choroidal lesions. Vision may fail early or late, depending on whether there is early or late degeneration of the papillomacular bundle. The prognosis for vision is bad, although subdural arsphenamized serum injections give some patients interruption of the progressive degeneration.

Tuberculosis affects the choroid, the macula, and the veins of the retina. Choroiditis areolaris is a rare form of disseminated choroiditis in which the foci develop in an eccentric manner, first appearing around the macula and then around the periphery. The behavior of the pigment is peculiar, as the fresh spots do not show exudation, but are entirely black and continually enlarge at the borders, while the centers become white. Tuberculosis is the usual but not the only cause; syphilis also must be suspected. *Tubercles* form in the choroid, in miliary tuberculosis appearing as white spots, in chronic tuberculosis as a single granulomatous patch with exudation. *Isolated macula degeneration* may occur as a focal lesion. Tuberculosis periphlebitis leads to destruction of the wall of the vein with hemorrhages and whitish exudate.

Arteriosclerotic, Nephritic, and Diabetic Retinosis.—The word "retinitis" as in albuminuric arthritis and diabetic retinitis is obviously a misnomer, and I adopt the change to "retinosis" as used by Troncoso and others.

All three forms—arteriosclerotic, nephritic, and diabetic—of retinal changes are essentially the same, depending on the change in the vessels. Forms of kidney degeneration with arterial change, such as nephrosis or the kidney of pregnancy, have an entirely distinct and different appearance from those due to glomerulonephritis in which the essential change is in the arterioles of the glomeruli. The young patient with severe diabetes never has retinal changes. The cause of diabetes in the middle-aged diabetic patient is change in the arterioles going to islets of Langerhans. Diabetic retinitis occurs "usually in patients over 50 years of age." (Troncoso.) In these patients nephritis and diabetes are often associated, so it would be impossible to decide which retinal changes are nephritic and which diabetic. It is true that albuminuric retinosis

produces the stellate white figures about the macula, which are characteristic and not found, it is said, in diabetes; that, however, is a minor point, and aside from it there are no characteristic nephritic or diabetic retinal changes.

Naturally the retinal picture of this syndrome is quite variable, depending on the stage and severity of the process and the particular accidents which occur to the retinal vessels. The observer should note:

1. *The Vessels*.—The arteries are tortuous and show light streaks along their course. This is easy to understand if you will draw a diagram of an artery with thin walls and a large lumen, and beside it an artery with very thick walls and a wide lumen. The thick walls obscure the red stream of blood underneath, which gives to the normal artery its red appearance, causing the artery to appear as a white streak. The veins are also tortuous and may be compressed where an artery crosses them. The amount of compression depends on the stage of progress of the thickening of the artery. Sometimes it makes only a nick in the vein. Sometimes the vein is enlarged and bulbous distal to the site of its crossing with the artery.

2. *Hemorrhages*.—These are seen as irregular, dark red splotches of variable size. In most instances the vessel from which the hemorrhage emerged can be made out, but not always. In case the hemorrhage is from a capillary the vessel is not visible, and the hemorrhage stands alone. The hemorrhages may be few and small or so massive as to dominate the entire retinal picture.

3. *White Spots*.—The generally accepted explanation of these is that they are fatty (lipoid) deposits, and are caused by the incomplete nutrition of the retina due to the diminished permeability of the vessels. Some white spots may be connective tissue or spots of edema.

Nephritic Retinosis.—The disc is early congested and its margins are blurred and indistinct, more often on the nasal than on the temporal side. There may rarely be some elevation of the disc when the hypertension is of the malignant variety. The white spots about the macula often take on the shape and figure of a star, although the novice who expects this as an infallible diagnostic sign will be disappointed, as it is not always present.

In *diabetic retinosis* the white spots tend to cluster around the disc, recalling Hirschberg's classic description of central punctate diabetic retinosis.

Retinal Changes in Brain Tumor.—The characteristic and specific change of the retina in brain tumor is papilledema, or choked disc. It is a finding of real diagnostic value, not simply confirmatory like the retinal images in other conditions.

While other explanations of the cause of choked disc have been offered, common sense approves the one based on histologic as well as experimental evidence, which states that the cerebrospinal fluid is forced by the increased intracranial pressure into the nerve, making its way finally into the intervaginal space of the nerve head. Schwalbe, in 1869, showed that the subarachnoid spaces in the brain communicate with the intervaginal spaces of the optic nerve. They make their way along the nerve between the nerve fibrils. Histologic sections of the nerve head show it protruding into the vault of the eyeball with the intervaginal space surrounding the nerve tissue greatly distended. Cushing and

Bordley demonstrated experimentally that by the introduction of liquid under constant pressure into the subdural space of the brain in dogs, when the fluid pressure was in excess of the venous pressure, the retinal veins became engorged and a measurable amount of swelling appeared in the papilla.

In the early stages of papilledema the disc appears wider than normal, the edges are fuzzy, lack sharpness, and there is a dim halo of edema around the disc. This widening is explicable when one has seen histologic sections, in which it is easy to demonstrate that the disc not only enlarges upward into the posterior chamber, but spreads out laterally. The central excavation remains. The color of the disc in the earlier stages is gray or grayish-red and is translucent. It has been compared to ground glass. There is a marked increase in the disproportion in size of the veins and arteries, the veins being engorged and enlarged, tortuous, and of a darker color. The surrounding retina shows *no change*. Vision at this stage may be little impaired because the nerve fibers are not themselves necessarily much damaged.

Later, the disc is very evidently elevated. The fact that the vessels can be seen to rise from their point of emergence over the crest and on the far side sink into the retina, demonstrates roughly the extent of the elevation. The physiologic elevation is lost. The papilla also spreads out laterally with indistinct margins, sending out tongue-like projections into the retina. There are likely to be hemorrhages and white spots in the retina in this later stage.

The site of the brain tumor is of more importance than its size in the production of papilledema. Tumors in the posterior cerebral fossa and the cerebellum are most commonly complicated by choked disc. The subtentorial tumors compress the aqueduct of Sylvius and the great vein of Galen, blocking the circulation of the cerebrospinal fluid in the ventricles and producing ventricular dilatation.

Of course, choked disc will be caused by any space-occupying mass in the cranium, whether strictly speaking a tumor or not, such as aneurysm, gumma, internal hydrocephalus, thrombosis of the sinus, etc. Malignant hypertension is also reported as producing some choking.

Toxemia of Pregnancy, Kidney of Pregnancy.—Visual disturbance in the course of pregnancy should always call for an ophthalmoscopic examination. The retinal picture is likely to resemble nephritic retinosis. Detachment of the retina, either wholly or in part, is, however, a frequent integral item, which is likely in those toxemias accompanied by generalized bodily edema.

Leukemia has retinal changes in about one-third of the cases, of either the myeloid or lymphatic variety. The "white blood" gives the retina a light yellowish or orange color. The veins are enormously enlarged and hemorrhages with a characteristic white center can be seen.

Retinal changes occur in pernicious anemia, erythremia, and purpura, but are of little interest except to the special investigator.

Embolism of Central Retinal Artery

On December 17, 1858, Graefe was consulted by a patient who had suddenly lost the sight of the right eye. While at work he had perceived a cloud

to form, which gave misty outlines to all objects. The field of vision then rapidly contracted, and in a few minutes the perception even of light was gone. He was suffering from endocarditis. On ophthalmoscopic examination the disc was very pale, and the vessels were reduced to a minimum. The arterial branches beyond the disc were like fine lines. The veins were smaller than normal in all places, but toward the periphery they increased in size. The left eye was normal in all respects.

Modern experience has added little to the description which Graefe gave of this first case ever seen. The retina becomes white, due to lack of nutrition of its inner layers. In the region of the macula these layers are missing, and the macula appears as a vivid cherry red spot. This is a characteristic, and practically pathognomonic, sign of occlusion of the central artery, for it is found nowhere else except in amaurotic family idiocy. If, by good chance, a cilioretinal artery exists on the disc, the territory of the retina supplied by this artery does not die, and therefore a small island of vision remains.

I have seen several cases of this condition in patients with mitral stenosis and embolism.

Spasm of the retinal artery occurs under the same circumstances as spasm of the coronaries or spasm of the leg muscles causing intermittent claudication. The symptoms though temporary are the same as for total occlusion.

Thrombosis of the central retinal vein results in severe congestion and numerous large hemorrhages. The usual causes are sepsis, syphilis, nephritis, and diabetes.

OTOSCOPY

The eardrum, as seen through the otoscope, has a pearly gray shining appearance. Its most prominent feature is the bony ridge which represents the attachment of the handle of the malleus, or manubrium: it is broader at the upper end, and extends downward and backward to a point somewhere near the middle of the drum where it ends in a gray spadelike expansion, the umbo. Extending from the lower end of the handle, downward and forward, is a bright reflection, the cone of light. The line of the handle and the cone of light divide the drum into the posterior fold and the anterior fold. Above the short process of the handle is an area known as the membrana flaccida, or Shrapnell's membrane.

Acute suppurative otitis media occurs as a complication of any infection of the throat. Its incidence in scarlet fever is 15 per cent, in measles 10 per cent, in pertussis 5 per cent. The eardrum is scarlet red, ecchymotic, swollen, and bulging, with the landmarks of the handle, etc., obscured. A blister can often be seen in the posterior fold. The yellow color of pus is usually obscured by the intense inflammatory redness of the membrane. Perforation, if it occurs, takes place at the site of one of the interlamellar abscesses, or at the most bulging part of the drum head in the posterior inferior fold. The perforation appears as a small, dark spot with a pulsating drop of pus covering it. The complications are mastoiditis, meningitis, brain abscess, cavernous sinus thrombosis, and

labyrinthitis. Gradenigo's syndrome is diplopia, due to homolateral abducens paralysis and pain in the temperoparietal region with an acute otitis media. The sixth nerve is involved at the tip of the pyramid of the petrous bone.

Chronic suppurative otitis media is a sequel of acute otitis media. Inspection of the drum head usually encounters pus entirely filling the external auditory meatus. After removing this it may be that inspection reveals an almost completely destroyed drum head with pus trickling down the long process of the incus into the atrium of the middle ear. Perforations should be made out: if at the edge of the drum they indicate bony necrosis; if at the center, inadequate drainage; if on the membrana flaccida immediately above the short process of the malleus, necrosis of the malleus. Numerous small perforations suggest tuberculosis. Polypi, or granulations, may protrude from the perforations, even partially filling the external auditory canal.

Otosclerosis.—Chronic catarrhal deafness. The drum head is retracted in most cases, in all if the Eustachian tube is closed. This gives rise to a change in the color of the drum and modifies the reflections from its surface. The cone of light is diminished in size, is broken up into one or two whitish spots, or entirely disappears. The drum head presents an uneven appearance. Points of adhesion to underlying structures can be made out by the depressions they cause. Calcareous spots can sometimes be identified.

Syphilis of the Internal Ear.—Hutchinson's triad for congenital syphilis consists of interstitial keratitis, notched teeth, and deafness. Statistics vary as to the number of children with congenital syphilis who are deaf; from 60 per cent to 33 per cent. Dennie's studies (*Congenital Syphilis*, Lea & Febiger, 1940) indicate that the prevalence of syphilis among deaf mutes is about 1.26 per cent. The following data as to congenital syphilitic deafness are pertinent: age at which it is found—eight to fifteen years. More common in females than in males. The onset may be sudden, and the course intermittent, continuous, or stationary. It often begins with dizziness and may be mistaken for Ménière's disease. The tympanic membrane may be normal, atrophied, or thickened. Air conduction is reduced or lost. Bone conduction is normal or decreased. Loss of high note perception is characteristic. The Rinne test is positive. Hennebert's pneumatic test is positive. The deafness nearly always becomes bilateral.

Acquired Syphilis.—Bilateral sudden spontaneous (not from head injury or cranial fracture) deafness is always due to syphilis: in an uncertain world this is as near to an unqualified statement as can be made. It may occur during the primary, secondary, or tertiary stages. Politzer reported an instance beginning seven days after the chancre appeared, but characteristically it is a third stage or even parasyphilitic manifestation. The nature and locale of the lesion are less certain. It is internal ear deafness. No sign is observed on the drum. The older view was that the cochlear membrane and that of the labyrinth, since disturbances of equilibrium are almost as troublesome as the deafness, are the parts involved. But more recent studies incline to the belief that the nerve degeneration occurs before the sensory end organs are affected. (For a full discussion see Mackenzie: *Am. J. Syph.*, 1917.)

LARYNGOSCOPY

Indirect laryngoscopy should be an accomplishment of the general clinician. Direct laryngoscopy, as well as bronchoscopy, may be left to experts.

In the mirror image of indirect laryngoscopy, the epiglottis is seen at the top. The true vocal cords appear beneath it, their attachment to the thyroid cartilage being hidden. These spread out and can be seen at the bottom of the image attached to the processus vocalis and anterior surfaces of the arytenoid cartilages. Along the outer sides of the true vocal cords, and on a slightly higher level, lie the ventricular bands, or false vocal cords. The arytenoid cartilages at the bottom of the image are marked by small rounded prominences, the two tubercles of Santorini in the middle, and the cuneiform tubercles at the sides.

The Pathologic Larynx

Edema of the larynx extends into the epiglottis and the arytenoid folds. Its cause may be (1) infectious, such as abscess of the larynx, Ludwig's angina and peritonsillitis, diphtheria, tuberculosis, syphilis; (2) chemical and irritative from the inspiration of noxious gases or the accidental inspiration of liquids or a foreign body into the larynx; (3) general disease, such as nephritis, heart failure, and notably the rare disease, angioneurotic-edema. The laryngoscopic picture of impending stenosis consists of the swollen epiglottis and arytenoids.

Acute infectious laryngitis occurs as a complication of the common cold, bronchitis, measles, German measles, scarlet fever, and smallpox. The laryngeal picture is that of any acute inflammatory process, the most striking feature being the redness of the vocal cords, and the epiglottis. The superficial layer of epithelium is largely shed and the submucosa is infiltrated and swollen.

Diphtheria of the Larynx.—The danger, added to the intrinsic danger of the disease, is laryngeal stenosis. The membrane may develop so rapidly that stenosis is present within twenty-four hours. There is early a dry, short paroxysmal cough. Cyanosis with full neck veins and sweating head are characteristic. As stenosis advances the inspiration is prolonged and attended by a whistling noise. The severe paroxysms of cyanosis and strangling come in waves. The child sits up suddenly and falls back exhausted. All the accessory muscles of respiration are called into action.

Tuberculosis of the Larynx.—It is now generally believed that laryngeal tuberculosis is always secondary to pulmonary involvement. The old argument, however, as to whether there is primary laryngeal tuberculosis, serves to emphasize the fact that it may occur so early in the general process that the pulmonary lesion is difficult to establish, and, therefore, the evidence from examination of the larynx is important.

The forms and stages of laryngeal tuberculosis are infiltration, ulceration, perichorditis, and granuloma.

The structures are usually involved in the following order: (1) the interarytenoid region; (2) the arytenoids; (3) the vocal cords; (4) the ventricular bands; (5) the epiglottis.

Recognition of the very earliest stages is important for two reasons: first, treatment in the early stage offers some hope, none in late involvement, and second, it indicates the stage or even confirms the existence of the pulmonary involvement.

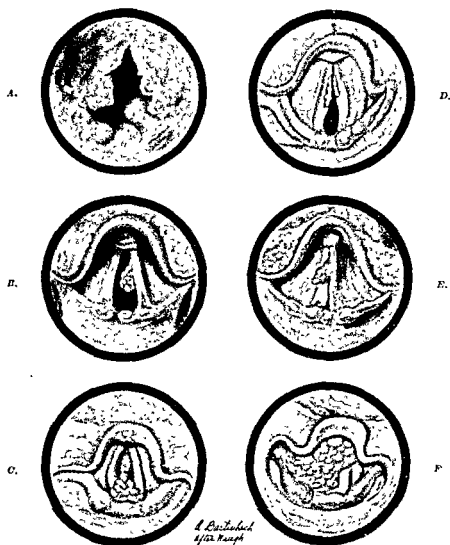


Fig. 141.—A. Extreme tuberculosis of throat and larynx. B. Tumor of larynx. Appearance of growth on respiration. C. Papilloma of larynx. D. Keratosis of larynx. E. Tumor of larynx. Appearance of growth on phonation. F. Papilloma.

The earliest appearance is the general ashen gray color of the whole larynx. It is ascribed to the secondary anemia of the disease. Many laryngologists, however, do not consider this sign of significance but believe hyperemia with catarrh is the earliest change. It is only when the catarrh and hyperemia begin to

localize on one side, however, that it is of significance; patients with pulmonary tuberculosis are subject to general laryngeal catarrh from coughing and exposure, but when unilateral localization occurs, actual tuberculous involvement must be considered.

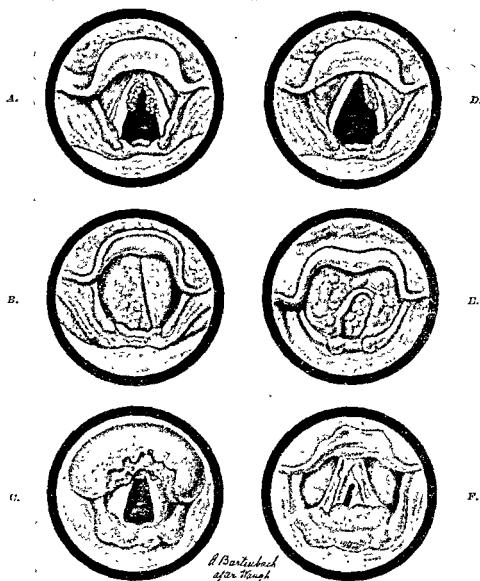


FIG. 142.—A. Carcinoma of the larynx. B. Advanced carcinoma. C. Tertiary syphilis. Gumma of the epiglottis, showing deep craterlike ulceration. D. Carcinoma. E. Very advanced carcinoma. F. Tertiary syphilis. The vocal cords have been the seat of former ulceration which now has cicatrized into partial union of the cords. The posterior boundary of the glottis is occupied by pinkish-yellow syphilitic mammillated outgrowths.

Next, is wrinkling of the posterior commissure, the interarytenoid space. The interarytenoid space should be watched in all cases of pulmonary tuberculosis, for the first definite changes predominantly occur there. After

Swelling, redness, and ulceration of a ventricular band are almost always secondary to the previous changes.

By the time the epiglottis swells with granulomatous infiltration, the entire larynx is involved, swallowing is painful and difficult, and the prognosis is hopeless.

Tubercle bacilli can be found in 90 per cent of cases of laryngeal involvement. A tuberculin test may be dangerous, leading to edema and laryngeal stenosis.

Syphilis of the larynx may be of the congenital, or acquired variety. The congenital manifestations are those of the tertiary stage with gumma, differing hardly at all from the similar lesions in the acquired form. The age incidence is typically ten to fifteen years.

Acquired syphilis affected the larynx in 3 per cent of 20,000 patients recorded by Lewin, of Berlin. All but a small number of these manifested the secondary stage catarrh (Lewin's erythema). Mucous patches and condylomata occur, but with the greatest rarity. Tertiary syphilis of the larynx consists of diffuse gummatous tumefactions of the epiglottis, interarytenoid fold, and more rarely the vocal cords, causing great distortion, easily made out on the laryngeal mirror. Because the larynx is a busy spot they break down rapidly with or without treatment. Healing leaves extensive scarring with hoarseness or aphonia to the extent that the victim communicates in whispers. The patient whom I observed for the longest period, became a town character under the name of "Whispering Billy."

Neoplasms of the Larynx.—Benign neoplasms are papilloma, fibroma, cystoma, and angioma; all tend to involve the margins of the cords and may remain stationary for years, causing little discomfort beyond hoarseness.

Carcinoma may be of the basal cell or squamous cell type. Its location may be on a vocal cord (intrinsic), extrinsic, subglottic, or mixed. Intrinsic vocal cord involvement accounts for 70 per cent of all cases. It always involves one cord only, and in most instances the free edge of the anterior two-thirds (i.e., toward the epiglottis). Five per cent of intrinsic cancers involve the ventricular bands or the ventricles. The appearance of the early intrinsic growths is typically papillomatous. On finding one, a biopsy is indicated for confirmation.

The extrinsic cancers arise from the epiglottis, the aryepiglottic folds, the arytenoids, or the piriform sinus. They are usually squamous-celled, with early lymphatic involvement.

A subglottic growth may be seen peeping from under the vocal cords on relaxed respiration.

Late destructive changes may cause the collapse of the entire larynx.

Paralyses of the Vocal Cords.—The intrinsic muscles of the larynx are all innervated from the vagus by the superior laryngeal and recurrent laryngeal nerves.

Paralysis may be of central origin, usually including tabes, but also from hemorrhage or tumor, syringomyelia or multiple sclerosis, producing the

syndrome of Avellis (ipsilateral paralysis of the soft palate, vocal cord, and partial paralysis of the constrictors of the pharynx and esophagus), the *syndrome of Tapia* (ipsilateral paralysis of the vocal cord, one-half of the soft palate and tongue), and the *syndrome of Schmidt* (paralysis of both vocal cords, the palate and the sternomastoid and trapezius muscles).

Peripheral paralysis of the recurrent laryngeal nerve occurs as a result of pressure from aneurysm of the aortic arch and from the dilated auricle of mitral stenosis. Peripheral paralysis of either or both the nerves also results from diphtheria and other infections, lead and other metal poisonings, and severance of the nerves during thyroid operations.

Chapter 30

BRONCHOSCOPY AND ESOPHAGOSCOPY

Bronchoscopy is the term applied to endoscopic examination through an electric lighted tube, and, while originally resorted to for the removal of foreign bodies from the air passages, it has even broader usefulness in the diagnosis and treatment of diseases of the larynx, hypopharynx, and tracheobronchial tree.

Chevalier Jackson has been largely responsible for developing the technique of bronchoscopy. For a complete description of instruments for peroral endoscopy and their techniques of usage the reader is directed to the important monograph on this subject by Jackson and Jackson. (*Diseases of the Nose, Throat and Ear*, Philadelphia, 1945, W. B. Saunders Co.)

Because bronchoscopy has seemed a formidable procedure, the diagnostitian has been slow to utilize the bronchoscope as a means of diagnosing obscure diseases of the air passages. However, since "look and see" is the order of the day in physical diagnosis, widespread interest and remarkable development of peroral endoscopy has resulted. In every accessible region of the body the aid of direct vision is called upon to contribute to diagnosis and treatment. The diagnostitian in thoracic disease can inspect, palpate, percuss, and auscult from the outside, and the roentgenologist can, in a sense, look through the patient, but it remains for the endoscopist to look into the bronchial tree.

Bronchoscopy should be resorted to not only in obscure pulmonary disease but also when indicated in the more common diseases, since many of these are secondary to undiagnosed lesions in the tracheobronchial tree. Some of the indications for bronchoscopy are:

1. Foreign body.
2. Suspected bronchiogenic carcinoma.
3. Postoperative atelectasis.
4. Lung abscess.
5. Bronchiectasis.
6. Recurrent or unresolved pneumonia.
7. Unexplained cough or hemoptysis.
8. Broncholithiasis.
9. Pulmonary tuberculosis.
10. Rare pulmonary infections, such as the mycoses or syphilis.
11. Tumors, stenoses, or anomalies.

The above conditions may be suspected (1) by the finding, on general physical examination, of unexplained physical signs, such as rhonchi, râles, and dullness; (2) by paralysis of recurrent laryngeal or phrenic nerve; (3) when x-ray examination indicates bronchial obstruction, emphysema, atelectasis, infiltration, cavitation, or mediastinal root shadows; or (4) when we have unexplained hemoptysis, cough, dyspnea, chest pain, or wheezing.

1. *Foreign Body*.—The air passages may be invaded by foreign particles from transference within the body (blood, pus, broncholith, secretion, sequestra, worms), introduced from without by aspiration, or by penetration (bullet, flying fragment). Carelessness in some form is responsible for most foreign body accidents. Usually a history is obtainable indicating introduction of the foreign element, but in its absence the finding of acute or chronic pulmonary suppuration should make one suspicious. All the symptoms are qualified by the size, shape, chemical composition, and the length of time it has been lodged in the air passages.

A careful history, physical examination, and roentgenologic study are needed as an indication for, or preliminary to, bronchoscopy. What were the date and details of the accident? Was there choking or gagging while the child had food or other substance in his mouth? Has there been any wheezing, cyanosis, pain, dyspnea, or fever? The quantity or quality of sputum is important, since bloody, foul, or increased sputum suggests an extensive period of foreign body lodgment. General physical examination of the patient should be made to rule out conditions hazardous to bronchoscopy, such as aortic aneurysm, hypertension, serious cardiac or renal disease, or the presence of disease of the central nervous system, such as tabes dorsalis. Laryngeal crises of tabes have been mistakenly thought due to foreign body.

In the *laryngeal* foreign body there is present one or more of the symptoms of croupy cough, hoarseness, aphonia, hemoptysis, dyspnea, apnea, wheezing, or cyanosis.

When in the *trachea*, in addition to the possible cough, dyspnea, hoarseness, or cyanosis, we hear the audible slap heard best during cough with the mouth open, the asthmatic wheeze heard with ear close to the patient's open mouth, or a palpatory thud.

Initial symptoms of a *bronchial* foreign body are coughing, choking, wheezing, etc., as in pharyngeal or tracheal involvement. The general signs and symptoms are those of a partial or complete obstruction. These have been classified by Jackson as (1) by-pass valve—partially closed; (2) check valve—air goes in but not out; (3) check valve—air emerges but cannot enter; and (4) completely shut valve—air passes neither in nor out.

The physical findings are dependent upon the extent of the obstruction, and include changes or absence of fremitus, expansion, percussion note, and breath sounds. Râles are found on the invaded side in partial obstruction distal to the foreign body, and in complete obstruction on the opposite side usually. McCrae (Clinical Features of Foreign Bodies in the Bronchi, *Lancet* 1: 735, April 12, 1924) well summarizes the physical signs as follows:

"There is no one description of physical signs which covers all cases. If the student will remember that complete obstruction of a bronchus leads to a shutting off of this area, there should be little difficulty in understanding the signs present. The diagnosis of empyema may be made, but the outline of the area of dullness, the fact that there is no shifting dullness, and the greater resistance which is present in empyema nearly always clear up any difficulty

promptly. The absence of the frequent change in the voice sounds, so significant in an early small empyema, is of value. A large empyema should give no difficulty. If difficulty remains, the use of the needle should be sufficient. In thickened pleura vocal fremitus is not entirely absent, and the breath sounds can usually be heard, even if diminished. In cases of partial obstruction of a bronchus, it is evident that air will still be present, hence the dullness may be only slight. The presence of air and secretion will probably result in the breath sounds being somewhat harsh, and will cause a great variety of râles, principally coarse, and many of them bubbling. Difficulty may be caused by signs in the other lung or in a lobe other than the one affected by the foreign body. If it is remembered that these signs are likely to be only on auscultation, and to consist largely in the presence of râles, while the signs in the area supplied by the affected bronchus will include those on inspection, palpation and percussion, there should be little difficulty."

2. In suspected *bronchogenic carcinoma* biopsy through the bronchoscope affords a means of confirming the diagnosis.

3. In *bronchiectasis* bronchoscopy serves (a) to demonstrate the presence of bronchial obstructive lesions, such as foreign body, tumor, or stenosis; (b) for introduction of lipiodol for bronchography; (c) to observe local foul pus of unmistakable odor substantiating the diagnosis; and (d) for therapeutic drainage of this pus through the bronchoscope.

4. Bronchoscopy is useful in *asthma* when allergy management fails to rule out tracheal obstruction. It also serves in *status asthmaticus* for the removal of mucoid secretions which the patient is unable to expel by coughing.

5. In *tuberculosis* we may secure aspirated bronchial secretions for diagnosis, or, when sputum remains positive after adequate therapy, determine the presence of tracheobronchial involvement, or before surgery identify a bronchial lesion.

6. For diagnostic purposes bronchoscopy is useful in *hemoptysis* that is not definitely associated with pulmonary tuberculosis, heart disease, aortic aneurysm, or pulmonary embolism. This procedure may disclose the hemoptysis as resulting from polyps, malignancy, adenoma, bronchiectasis, tracheobronchial tuberculosis, or broncholith.

7. *Atelectasis* or massive collapse of the lung is a frequent complication of major surgery today. The sooner bronchoscopy is resorted to for removal of aspirated mucoid secretions or saliva, the better the result. The superior anesthetist of today must be a well-trained bronchoscopist as well, and, if, during an operation, there has been much accumulation of mucus or saliva in the trachea, bronchoscopic aspiration should be carried out before the patient leaves the operating room.

8. Bronchoscopy often is of service in the drainage of *lung abscess*, in the diagnosis of *bronchial and tracheal stenosis*, and such rare pulmonary infections as *actinomycosis*, *blastomycosis*, and *leptothrix infections*.

9. Furthermore, bronchoscopy stands as an important adjunct to good *thoracic surgery*, by early diagnosis of lesions, and during and following operation by its administration in the care of the air passages.

ESOPHAGOSCOPY

Esophagoscopy is the examination of the esophagus with an endoscopic tube, and is indicated in any patient who complains of difficulty or pain in swallowing, or as a preliminary to the first blind passage of a flexible lens-system gastroscope. Through its use we may extract foreign bodies or observe diseased conditions.

As a preliminary to its use one should secure a careful history, make general physical examination, with special emphasis on the nose and throat, being careful to study the lips, tongue, palate, and pharynx. A mirror examination of the larynx and pyriform sinuses may disclose an ulcerative or inflammatory lesion of the larynx. An enlarged lingual tonsil may cause difficulty in swallowing. A preliminary fluoroscopy of the esophagus with opaque mixture, and roentgenogram, is frequently of great value.

Contraindications to its usage are the presence of aneurysm, advanced organic disease, extensive esophageal varicosities, and acute necrotic or corrosive esophagitis.

Chapter 31

PROCTOSIGMOIDOSCOPY

While the diagnosis of most colonic disorders is relatively easy, the careful history and routine physical examination will often suggest the need for special inquiry. The terminal three and one-half inches of the digestive tract can be palpated by the finger, and the interior of the lower ten to twelve inches can be looked into by means of a proctoscope and sigmoidoscope. If carefully done, this is not a painful procedure, and our success with the procedure as an adjunct to diagnosis requires that it be as painless as possible. We are aware that examination is often deferred by the patient because it is believed to be painful.

To assure a minimum of pain, the following points should be remembered: (1) the patient must be given an enema the night before and on the day of examination; (2) the instruments must be well lubricated; and (3) the patient should be examined in as comfortable a position as facilities permit. I believe the inverted position, first described by Hanes (Buie, L. A.: *Practical Proctology*, Philadelphia, 1938, W. B. Saunders, p. 29), made possible by a tilt table, is the best. Similar effectiveness can be secured by the knee-chest position, or by having the patient lie across a bed with his head and shoulders on a pillow on the floor.

As a preliminary to the examination, a careful inspection of the buttocks, separated by the hands, often reveals a painful condition, such as a fissure, contraindicating proctoscopy. If inspection is negative, digital examination is carried out (see Chapter 14, p. 432). After this is done, the confidence of the patient can be won by informing him that the insertion of the instrument will be no more discomforting than the finger.

There are many good proctoscopes and sigmoidoscopes with excellent lighting arrangements on the market today. If digital examination suggests a pathologic condition, the short proctoscope is inserted first; otherwise, the narrow gauge sigmoidoscope should be immediately used to avoid two insertions of instruments.

Never blindly insert the instrument further than the area explored by the finger, nor push it firmly against the bowel wall until the lumen ahead is identified by removing the plunger, so that, the field can be brought under direct observation. The great value of the inverted position is that, on removal of the plunger, air passes into the rectum ballooning the walls and making the insertion of the proctoscope under direct vision easy for both the patient and the examiner. When using the sigmoidoscope, it is inserted to its full length (10 to 12 inches) and then slowly withdrawn while careful scrutiny of the mucosal surface is made. Frequently long cotton applicators or suction is needed to keep the field clean for proper examination. On completion, the instrument is carefully and slowly withdrawn.

The proctosigmoidoscope is indicated for (1) general observation of the terminal ten inches of the digestive tract, (2) procurement of cultures; and (3) securing biopsy. Some of the diseases diagnosable by use of the sigmoidoscopic examination are as follows:

1. Carcinoma and Other Malignant Tumors.—About 75 per cent of carcinoma of the colon is in the terminal ten inches, and we should be on the lookout for this disease when the patient is over twenty-five years of age, and when one or more of the following conditions are present: (a) constipation or diarrhea; (b) passage of blood and mucus from the rectum; (c) pain, usually associated with defecation; (d) gas consciousness; (e) attacks of partial or abrupt complete obstruction (75 per cent of tumors of the left colon causes either partial or complete obstruction, usually chronic, but often quite abrupt); (f) abdominal mass; (g) unexplained loss of weight and strength.

Tumors of the rectum and anus may be confused with hemorrhoids. "Twenty per cent of patients with cancer of the rectum and anus have been subjected to hemorrhoidectomy within six months of the recognition of malignancy." (Pemberton, J., and Dixon, C. F.: Surg., Gynec. & Obst. 58: 462, Feb., 1934.) Therefore routine microscopic examination should be made of all tissues removed at anorectal operations.

The sigmoidoscopic examination may reveal the common encircling, sessile, nodular form, or the colloid type of adenocarcinoma without ulceration if made early in the disease. With ulceration comes bleeding and secondary infection which accounts for a degree of necrosis and its attendant fever, leucocytosis, tenderness, and cachexia.

2. Ulcerative Lesions.—Among these are: (a) *idiopathic ulcerative colitis* whose various stages, as demonstrated by the use of the sigmoidoscope, range from the very early hemorrhagic spots of pin-point size, to the second stage of general hyperemia with the mucosa somewhat swollen, which on mild trauma shows frank bleeding, and the third stage with red, edematous mucosa of granular appearance with oozing of free blood, and on to the severely acute fulminating stage, where the sigmoidoscope must be passed carefully, little or no normal membrane being visible, and the presence of a mucopurulent sanguinous exudate or a diphtheria-like membrane. The chronic phase shows a narrow tubular gelatinous-appearing lumen with complete loss of normal architecture. One finds 95 per cent of these cases in the rectum or terminal sigmoid.

(b) *Amebic Dysentery.*—Seldom do we fail to find amebic ulcers through sigmoidoscopy, and when frequent stool examinations fail to demonstrate the ameba, we very often can identify them from the exudate of ulcerated mucous membrane removed through the sigmoidoscope. The typical amebic ulcer is oval, punched out, and varying from 5 to 15 mm. in length, and usually has its surface covered with bloody mucus. The absence of inflammation between the ulcers differentiates amebiasis from ulcerative colitis.

(c) *Bacillary Dysentery.*—Here the sigmoidoscopic examination shows a hyperemia of the entire mucosa, with small bleeding ulcers which cannot be distinguished from ulcerative colitis. In the chronic stage it may also show the picture of idiopathic ulcerative colitis.

3. **Benign Polyps.**—These are usually located in the rectum or terminal sigmoid. The rare *adenomatous polyposis* is differentially diagnosed by the use of the sigmoidoscope.

4. **Strictures** of the rectum or sigmoid can be correctly observed only by proctosigmoidoscopy.

The location of *foreign bodies*, *factitial proctosigmoiditis*, and *melanosis coli* is likewise a feature of the usefulness of the proctosigmoidoscope.

For the securement of *cultures* the removal of material for bacteriologic study from the rectum or sigmoid through the sigmoidoscope is often indicated. Long sterile cotton applicators or a metal spoon or curette serves for this purpose. Similar means is resorted to for the securement of material for parasitic study.

Furthermore, the sigmoidoscope quite naturally serves for the purpose of securing *biopsies* of questionable tumors of the rectum and sigmoid.

Chapter 32

GASTROSCOPY AND PERITONEOSCOPY

While the diagnostic values and limitations of esophagoscopy and proctosigmoidoscopy are well known to the clinician, the diagnostic value of the gastroscope, a rather recent addition, has not yet been fully appraised. Bockus says (Bockus, Henry L.: *Gastroenterology*, Philadelphia, 1943, W. B. Saunders, Vol. I, p. 235), "Unquestionably the flexible gastroscope is opening up new diagnostic channels. The method has already justified itself in the study of some patients with a suspicion of stomach disease . . . gastroscopy should be called upon in any case in which the diagnosis remains obscure after the application of roentgenography and other diagnostic aids. Every gastroenterologic clinic should be equipped with a flexible gastroscope and its personnel should include someone trained in its use."

In the hands of one familiar with its use the lens-system flexible gastroscope of Wolf-Schindler (Schindler, Rudolph: *Gastroscope With the Flexible Gastroscope*, Chicago, 1937, University of Chicago Press) can readily and safely be used as an office procedure for the diagnosis of diseases of the stomach mucosa. The gastroscopy is performed on a fasting stomach. As a preparation the patient is given $\frac{1}{100}$ gr. of atropine hypodermically, followed by anesthetization of the throat by spraying with 2 per cent pontocaine. One grain of sodium phenobarbital may be given hypodermically to counteract any idiosyncrasy to pontocaine.

There are but few contraindications to the use of the flexible gastroscope. These are: 1. Disease of the esophagus. X-ray examination of the esophagus or open tube esophagoscopy should precede gastroscopy. 2. Disease of the mediastinum, such as aneurysm or tumor. 3. Acute febrile conditions of the abdomen and acute conditions of the stomach, such as acute gastritis. 4. Others that make the procedure difficult, such as deformity of the spine, heart failure, dyspnea of any cause, or a "difficult" patient.

Despite the fact that we are unable to visualize the entire stomach—the blind spots being an area on the greater curvature at the tip of the instrument, a strip of the posterior wall under the instrument, the upper part of the lesser curvature, and a part of the fornix above the cardia—the gastroscope serves well under the following conditions: (1) when x-ray examination is negative in suspected gastric disease; (2) abnormal or inconclusive x-ray findings; (3) gastric ulcer; (4) malignancy; (5) indeterminate conditions with stomach symptoms.

The gastroscope is the only means of establishing conclusively the diagnosis of gastritis. Montgomery and others (Peptic Ulcer, Gastritis and Psycho-

neurosis, J. A. M. A. 125: 890, July 29, 1944) found that 50 per cent of a large series of patients without demonstrable evidence of peptic ulcer suffered from some degree of gastritis. Renshaw (Renshaw, R. J. F.: Cleveland Clin. Quart. 11: No. 4, Oct., 1944) in his experience finds "gastroscopy of major value as the only or principal means of establishing the diagnosis in 25 per cent of all cases examined. The diagnosis in most of the cases comprising this 25 per cent was chronic gastritis. However, a significant number of gastric ulcers which had not been detected roentgenologically were found by gastroscopy. Also the diagnosis of a significant number of doubtful cases of benign and malignant tumors and ulcers was definitely established by gastroscopy."

Combined with fluoroscopy and study of gastric contents, gastroscopy has added much to the methods of diagnosis of diseases of the stomach.

PERITONEOSCOPY

Peritoneoscopy is the procedure of visualizing the peritoneal cavity by means of an optical instrument. Through this the liver, falciform ligament, omentum, anterior surfaces of the intestines, fundus of the gall bladder, pelvic viscera, parietal peritoneum, and sometimes the appendix may be seen. Ruddock (Surg., Gynec. & Obst. 65: 623, Nov., 1937) in a series of 500 examinations had but 8 operative accidents, with one death following biopsy of a metastatic carcinoma nodule of the liver. He reports that of 140 suspected cases of cirrhosis of the liver diagnosed by clinical means there were 20 incorrectly diagnosed, whereas by use of the peritoneoscope there were but 6 incorrectly diagnosed of 120 cases called cirrhosis. Of these six cases, two turned out to be malignancy, two normal, one hepatitis, and one incomplete examination. There was also a high percentage of accuracy of diagnosis in tuberculous peritonitis, peritoneal metastases, suspected malignancy of the liver, and 100 per cent accuracy in making the diagnosis of ectopic pregnancy in 13 cases of 31 suspected. Of the 18 cases incorrectly diagnosed clinically, 10 were intrauterine pregnancies, 4 were intrauterine pregnancies with pelvic inflammatory disease, 3 were pelvic inflammatory disease, and 1 a ruptured ovarian cyst. He reported a statistical study of 409 cases, showing 91.7 per cent accuracy of diagnosis as compared to the clinical accuracy of 63.9 per cent. He states in his summary "Peritoneoscopy should be selected in lieu of a diagnostic laparotomy where it is necessary to determine malignancies, metastases and extent of involvement, to differentiate tumor masses, and localize them, to examine the surfaces of viscera and pelvic organs, or to corroborate a diagnosis or to obtain biopsies. It should not be selected for use in cases with inflammatory lesions in the peritoneal cavity. The procedure cannot take the place of surgery, but, by making a definite and correct diagnosis, it may prove a valuable aid, if the case is an operable one and surgery is deemed necessary."

Two of the most practical uses of the peritoneoscope are in (1) ascites, in the differential diagnosis of cirrhosis of the liver, generalized abdominal carcinomatosis, and tuberculous peritonitis, and (2) liver disease, especially with

hepatomegaly. The contraindications are (1) acute inflammation in the abdominal cavity, (2) distention, because of danger of bowel perforation, (3) presence of known adhesions, and (4) the very obese patient. The examination is carried out in the operating room, with laparotomy technique. The patient need not be hospitalized more than one day. Although peritoneoscopy has been used for more than forty years, little usage is made of this important diagnostic procedure today, and the relative safety with which exploratory laparotomies can now be made will certainly not tend to increase its usage.

INDEX

A

A-V conduction time, prolonged, shown by electrocardiogram, 798

Abadie's sign, 574

Abdomen:

diseases of:

- abscess, cold, in, 476
- psaos*, 476
- allergy of, pain due to, 103
- appendicitis, 474-475
- "chronic," 475
- ascites, 453
- cholecystitis, 466-467
- cholelithiasis, 466-467
- colitis, ulcerative, chronic, 480
- colon, carcinoma of, 771
- polyposis of, 771
- diverticulitis, Meckel's, 457
- of sigmoid, 479
- ectopic pregnancy, 458
- fecal impaction, 478
- frequency of, relative, 453
- gallbladder, diseases of, 466-467
- bile ducts, carcinoma of, 122
- gallstones, 122
- hemorrhage, 460
- Hirschsprung's disease*, 455
- ileitis, regional, 475
- ileoceleal tuberculosis, 476
- ileus, paralytic, 458
- intestinal obstruction, 437
- liver, diseases of:
- abscess, 472
- atrophy, yellow, acute, 459
- cirrhosis, 469-470
- cysts of, 472
- enlargement, causes of, 468
- hepatomegaly, 468
- syphilis of, 471
- tumors of, 472
- lymphoma, 462
- Meckel's diverticulitis, 457
- mesenteric thrombosis, 458
- ovary, tumor of, 458
- pancreas, diseases of:
- carcinoma of, 473
- hyperinsulinism, 237
- inflammation, acute, 468
- lithiasis (stone), 473
- pancreatitis, 468
- tumors of, 473
- peritonitis, 459
- psaos* abscess, 453
- sigmoid diverticulosis, 479
- spleen, diseases of, 463-465
- abscess of, 465
- cysts of, 464
- Gaucher's disease of, 463
- hematoma of, 464
- Niemann-Pick's disease of, 463
- thrombosis of splenic vein, 464
- stomach, diseases of, 746-747
- achylia gastrica, 644

Abdomen, diseases of stomach—Cont'd

- acidity of, normal values, 644
- foreign bodies in, 759
- linitis plastica, 759
- syphilis of, 461
- tumor, benign, of, 700
- ulcer, peptic, *nichte in*, 732
- types of, 751
- thrombosis of inferior vena cava, 454
- mesenteric, 455
- tuberculosis of, 476
- ileoceleal, 476
- tumors, 462
- ovarian, 458
- pancreas, of, 473
- right lower quadrant, 477
- Von Gierke's disease of, 456
- examination of, routine, 445
- inflammation of, 461
- pain in, 92
- frequency of, 99
- Lennander's experiments in, 92
- referred, 98
- Abdominal reflex, 537
- Abscess, brain, 614, 657
- Brodie's, 500
- of liver, 472
- of lung, 423, 425
- examination of, by x-ray, 714
- periapical, examination of, by x-ray, 732
- psaos*, 476
- retropharyngeal, 253
- splenic, 465
- subphrenic, 433-434
- examination of, by x ray, 728
- Achondroplasia, 482
- Achylia gastrica, 644
- Acidosis, 634-635
- Acrocyanosis, 519
- Acromegaly, 215-216
- examination of, by x-ray, 684
- in head, 239
- Leonard Mark's description of, 216
- pituitary hyperfunction in, 215-216
- Actinomycosis, examination of, by x-ray, 680
- of lungs, 428
- in neck swelling, 268
- skin eruption, granulomatous due to, 194
- x-ray examination of, 640
- Adams Stokes syndrome, 306-307
- Addison's anemia, 575
- disease, 244
- skin in endocrine gland disease, 232
- skin pigmentation due to, 204
- Adenoids, 239
- Adenoma, hyperinsulinism due to, 237
- of parathyroid, 218
- Adie's pupil, 574
- Adiposis dolorosa* (*Dercum's disease*), 178, 506
- Adrenal gland, tumor of, adrenogenital syndrome, 224
- Adrenogenital syndrome, 224
- Agranulocytic angina in mouth diseases, 249

- Albumin serum in blood, 638
tests for, 618
in urine, 618 619
- Albuminuria, causes of, 619
orthostatic, 619
retinosis, 820 821
- Alcoholic intoxication, equilibrium disturbance due to, 608
neuritis, 563
- Alcoholism, delirium in, 153
- Alkalosis, 634 635
- Allergy, 103, 497
abdominal, pain due to, 103
hydnarthrosis, intermittent, 497
- Amenorrhea, 230
- Amphoric breathing, 400
- Amylase, in blood, 637
normal value, 629
- Amyotonia congenita (Oppenheim's disease), 582
- Amyotrophic lateral sclerosis, 543, 570
spinal fluid in, 658
- Anal fissure, 532
- Anchondroplasia in head diseases, 238
- Androgyny, 181
- Anemia, Addison's, 575
pernicious, 575
skin changes due to, 206
secondary, skin changes due to, 206
- Anesthesia, 602
due to cervical rib, 112
cortical, 605
due to hysteria, 113
hysterical, 605
in leprosy, 603
due to nerve injury, 112
due to syringomyelia, 112
due to tabes dorsalis, 112
of trunk, 574
- Aneurysm, 510
of aorta, 392 393
dissecting, 397
rupture of, 393 394
arterial, 393-394
arteriovenous, 394, 523
of axillary artery, 521
dissecting, 397
examination of, by x-ray, 700
of femoral artery, 521
in myocardium disease of, 390
myotic, 395
neck pulsation due to, 267
pain due to, 91
of popliteal artery, 521
x ray examination of, 700
- Angina, agnathocytic, 249
Ludwig's, 275
pectoris, 139, 366 367
differential diagnosis of, 140
- Anginal, thoracic, syndrome, pain in, 90
- Angioneurotic edema, 200
- Ankle clonus reflex, 536
jerk reflex, 536
- Anomalies, congenital, examination of, by x-ray, 688 689
- Anorexia, causes of, 115
nervosa, 180
- Anterior crural paralysis, 540
poliomyelitis, 560-561
syndromes of, 561
tibial paralysis, 540
- Anthrax, in neck swelling, 268
skin eruption, granulomatous due to, 194
- Anuria, causes of, 128
- Aorta, diseases of, 387-391
aneurysm, 392-393
dissecting, 387
rupture of, 393 394
aortic valve, diseases of, 341
aortitis, 390-391
pain due to, 91
syphilitic, 389 394
arteriosclerosis of, 388 389
atheroma, 388-389
coarctation of, 345, 348, 699-700
congenital, 345
examination of, by x ray, 699-700
congenital coarctation of, 345
examination of, by x ray, 697
murmur, Austin Flint's, in aortic regurgitation, 343
occlusion, 387
regurgitation, aortic, Austin Flint's murmur in, 343
neck pulsations in, 267
rupture of aneurysm, 393 394
sclerosis, arterial, of, 388-389
stenosis, 343 344
syphilis of, 389 394
dyspnea, paroxysmal due to, 131
valve, aortic, diseases of, 341
x ray examination of, 697
- Aortic regurgitation, 341-343
Austin Flint's murmur in, 343
neck pulsations due to, 267
valve diseases of, 341
- Aortitis, 390 391
pain due to, 91
syphilitic, 389 394
- Appendicitis, 474 475
"chronic," 475
Hertler, Arthur E., on, 15
examination of, by x ray, 765
pain due to, 96
x ray examination of, 765
- Apex beat, palpation of, 316
- Aphasia, 606
- Apoplexy, 568
- Arachnoid hemorrhage, stupor due to, 615
- Aran-Duchenne progressive muscular atrophy, 579
- Argyll Robertson, Douglas, pupillary reaction, 264, 572
- Argyria, skin discoloration due to, 204
- Arithmavin, 243
- Arm, atrophy of, 486
pain in, 92
- Arrhenoblastomata of ovary, 224
- Arrhythmia, sinus, 309 310
shown by electrocardiogram, 785
- Arsenical neuritis, 564
- Arterial venous aneurysm, 394, 523

- Arteriosclerosis, 353, 514-516
 of aorta, 388-389
 cerebral, 612
 mental state due to, 612
 tremor due to, 585-586
- Artery, axillary, aneurysm of, 521
 cerebellar, posterior inferior, occlusion of,
 signs of, 559
 symptoms of, 559
 cerebral, pain due to distension of, 82
 coronary, disease of, electrocardiogram in,
 802-811
 occlusion, 368, 370
 femoral, aneurysm of, 521
 mesenteric, superior, embolism of, pain due
 to, 103
 popliteal, aneurysm of, 521
- Arthritis, 488-499
 examination by x-ray, 689-693
 gonococcic, 491-492
 noninfectious, backache due to, 106
 osteo-, 490
 pneumococcic, 493
 rheumatoid, 488-489
 syphilitic, 490
 syringomyelic, 497
 tuberculous, 490
 x-ray examination of, 689-693
- Ascites, 453
- Asthenia, neurocirculatory, of tachycardia,
 306
- Asthenic syndrome, 189
- Asthma, 133, 411-412
 bronchial, 410-412
 cardiac, 133
- Ataxia, 571-576
 cerebellar, 575
 gait, 548
 Friedreich's, 575
 gait, 546
 locomotor, 571
 Marie's, 576
 paralysis, 540
- Atelectasis, bronchoscopy in, 833
 of lungs, 427
- Atheroma, of aorta, 388-389
- Atheromatosis, cholesterol in, 637
- Athetosis, 541, 590
- Atrophy, 579-580
 Aran-Duchenne progressive muscular, 579
 of arm, 486
 Charcot-Marie neural peroneal, 580
 facioscapulohumeral, of Landouzy-De
 jerine, 579
 juvenile scapulohumeral, of Erb, 579
 Landouzy-Dejerine facioscapulohumeral,
 579
 of leg, 486
 of Leyden-Moebius, 580
 muscular, progressive, 180
 of Aran-Duchenne, 579
 neural peroneal, of Charcot-Marie-Tooth,
 580
 of Werdnig-Hoffmann, 580
 yellow, acute, of liver, 459
- Auenbrugger, percussion, classic description
 of, 164
- Aura, 85-86, 591
 of epilepsy, 591
 in migraine, 85
 motor, in migraine, 86
- Auricular extrasystoles, shown by electro-
 cardiogram, 788
- Abrillation, 312
 shown by electrocardiogram, 789-791
- Flutter, 306
- Auscultation, 164-165, 318-321
 Bushnell's observations on respiratory
 acoustics, 171
 decibel, the unit of sound in, 166
 Laennec's description of, 169
 methods of, 164-165
 origin of chest sounds, 170
 thorax as a resonator in, 168-169
 transmission of chest sounds, 170
- Avellis syndrome, 557
- Axilla, swellings of, 281
- Axillary artery, aneurysm of, 521
- Ayerza's disease, 360
- Azorubin test for liver, 650
- B
- Babinski reflex, 537
- Babinski-Nageotte syndrome, 557
- Bacillary dysentery test, 667
- Backache, 104-110
 causes of, 104
 due to:
 brucellosis, 105
 intervertebral disk rupture, 108
 kyphosis, 107
 lordosis, 107
 lumbago, 109
 neuritis, 110
 nucleus pulposus rupture, 108
 osteomyelitis of spine, 105
 Paget's disease, 107
 rupture of intervertebral disk, 108
 nucleus pulposus, 108
 sacroiliac strain, 108
 scoliosis, 107
 spondylolisthesis, 109
 trauma, 107
 tuberculosis of spine, 104
 undulant fever, 105
 frequency of, 104
 reflex, 109
- Banti's disease, 464
- Bárány test, 610
- Barbiturates, delirium due to, 153
- Basal metabolism, 814, 817
 in children, 214
 determination, method of, 813-814
 in disease, 815-816
 in endocrine diseases, 817
 normal values, 815
 in thyroid diseases, 816-817
 values, normal in, 815
- Bell's palsy, 239
- Bence-Jones proteinuria, 620
- Benedict's syndrome, 560
- Benzedine test for blood in stools, 646
- Beri-beri, in heart disease, 381
- Bicep jerk reflex, 534

- Biernacki's sign, 574
 Bilirubin test, 649
 Biot's breathing, 175
 dyspnea in, 134
 respiration, 175
 Bismuth, skin discoloration due to, 204
 Bladder, diseases of, 127-128
 anuria, causes of, 128
 hematuria, causes of, 128
 incontinence, urinary, causes of, 128
 polyuria, causes of, 127
 due to nephritis, 127
 urinary pain in, 80
 urination, frequency of, 127-128
 urine, incontinence of, causes of, 128
 Blastomycosis, examination of, by x ray, 680
 of lungs, 429
 skin eruption, granulomatous, due to, 194
 Bleeding time, normal value, 623
 Block, bundle branch, shown by electro
 cardiogram, 801
 Blood:
 albumin, normal values, 622
 amylase, 637
 benzidine test for, in stools, 646
 bleeding time, normal value, 623
 calcium, 637
 carbon dioxide combining power of, 633
 cells, abnormal, 624-625
 red, 624-625
 white, 625
 cellular, normal values, 623
 chemistry, 629-639
 amylase, normal value of, 629
 calcium, normal value of, 629
 carbon dioxide, normal value of, 629
 chlorides, normal value of, 629
 cholesterol, normal value of, 629
 creatinine, normal value of, 629
 glucose tolerance, normal value of, 629
 iodine, normal value of, 629
 nitrogen, normal value of, 629
 nonprotein nitrogen, normal value of, 629
 normal values, 622, 629
 phosphatase, normal value, 629
 phosphorus, normal value of, 629
 potassium, normal value of, 629
 proteins, normal values of, 629
 sodium, normal values of, 629
 sugar, normal values of, 629
 urea, normal values of, 629
 uric acid, normal values of, 629
 chlorides, 638
 cholesterol, 636
 coagulating time, normal value, 623
 color index, determination of, 627
 creatinine in, 632
 culture, 671
 diseases of, in eye, 257
 in gums, 243
 hemophilia, 496
 of joints, 496
 examination of, 623-628
 formation of, 623-624
 fragility, normal value of, 623
 globulin, normal value of, 622
 glucose tolerance test, 632-633
 iodine in, 637
 leucocytosis, 626
 Blood—Cont'd
 leucopenia, 627
 lymphocytosis, 627
 nitrogen, nonprotein, 631
 normal values:
 albumin, 622
 bleeding time, 623
 cellular, 623
 chemical, 622
 coagulation time, 623
 fragility, 623
 globulin, 622
 prothrombin, 623
 sedimentation rate, 623
 phosphatase, 635-636
 phosphorus, 635
 pressure, 347-352
 clinical value of determination, 352
 high, causes of, 352
 low, causes of, 352
 methods of determining, 347-349
 normal range, 350-351
 proteins, 637
 prothrombin, normal value, 623
 red cells, 624-625
 saturation index, determination of, 628
 sedimentation rate, normal values, 623
 serum, 638
 albumin, 638
 globulin, 638
 in stools, 646
 benzidine test for, 646
 sugar in, 632
 normal value, 629
 tests, 632-633, 646
 benzidine, for blood in stools, 646
 glucose tolerance, 632-633
 urea, 631
 uric acid in, 631
 vessels, diseases of, 510
 aneurysm, 510
 embolism, 510
 volume, index determination of, 628
 white cells, 625
 Body, 175, 178
 contour, 178
 temperature, 175
 Boeck's sarcoid, 193
 Bones, 217, 500-503
 deformities of, 503
 destruction of, 217
 diseases of, 500-505
 fibrocytic bone disease, 238
 osteitis deformans, Paget's disease, 502
 503
 osteomalacia, 502
 osteomyelitis, 500
 Paget's disease (osteitis deformans) 502
 503
 rickets, 502
 scurvy, 502
 syphilis, 500
 tuberculosis, 500
 tumors, 501
 examination of, by x ray, 680-683
 formation of, 217
 pain in, 79
 Brachial neuritis, 597

- Bradycardia, Adams-Stokes syndrome, 306-307
 bundle branch block, 308
 due to heart block, 306-307
 shown by electrocardiogram, 795-801
 sinus, shown by electrocardiogram, 795
- Brain:
 abscess, spinal fluid in, 657
 stupor due to, 614
 pain in, 81
 tumor:
 headache due to, 89
 hemiplegia due to, 568
 mental state disturbance due to, 610-611
 retina in, 821
- Branchiogenic cysts, 275
- Breasts:
 carcinoma of, 284
 chronic mastitis of, 282
 examination of, methods of, 284-285
 inflammations of, 282
 mastitis, chronic, 282
 methods of examination, 284-285
 nipples, 284
- Breathing, 399-400
 amphoric, 400
 Biot's, 175
 bronchial, 399
 Cheyne-Stokes, 174
 cogwheel, 400
 Hippocratic, 174
 vesicular, 399
- Brewer's kidney, 462
- Brodie's abscess, 500
- Brom-sulfalein test, 650
- Bronchi, 406-412, 702-704
 diseases of, 406-410
 asthma, 410-412
 bronchiectasis, 406-407
 bronchoscopy in, 833
 examination of, by x-ray, 703
 bronchitis, 406, 408
 acute, 406
 chronic, 406
 fibrinous, 408
 broncholithiasis, 408
 pneumonia, 420
 examination of, by x-ray, 702-704
 foreign bodies in, 409
- Bronchial breathing, 399
- Bronchiectasis, 406-407
 bronchoscopy in, 833
 examination of, by x-ray, 703
- Bronchiogenic carcinoma, 424
 bronchoscopy in, 833
 cough due to, 142
- Bronchitis, 406
 acute, 406
 chronic, 406
- Broncholithiasis, 408
- Bronchophony, 400
- Bronchopneumonia, 420
- Bronchoscopy, 831, 833
 in atelectasis, 833
 in bronchiectasis, 833
 in bronchiogenic carcinoma, 833
 for foreign bodies, 832
 indications for use, 831
 surgery, thoracic in, 833
- Brown's sign in Buerger's disease, 518
- Brown-Sequard syndrome, 570
- Brucellosis, backache due to, 105
 skin test for, 671
 tests for, 667
- Buerger's disease, 518
 Brown's sign in, 518
 phlebitis migrans in, 513
 thrombo angitis obliterans in, 517-518
- Bundle branch block, bradycardia, 308
 shown by electrocardiogram, 798, 801
- Bursitis, 499
- Bushnell, Col. George E., auscultation observations on respiratory acoustics, 171
- C
- Cabot, Richard, case teaching in medicine, 1
- Calcium, in blood, 637
 normal value, 620
- Capillary dilatation, 193
 pulse, 314
- Capp's experiment in pain in pericardium, 79
 in pleural pain, 79
- Carbon-dioxide, combining power of blood, 633
 normal value, 620
- Carcinoma, of ampulla of Vater, 473
 of breast, 284
 bronchiogenic, 424
 bronchoscopy in, 833
 cough due to, 142
 of colon, examination of, by x-ray, 771-772
 proctosigmoidoscopy in, 836
 of spleen, 463
 of stomach, examination of, by x-ray, 757-758
- Cardiac asthma, 133
- Cardiospasm, x-ray examination of, 740-741
- Caries, 248
- Carnett, John Burton, on intercostal neuralgia, 100
- Carnett's sign, 448
- Carotid tumor, 275
- Carotinemias, skin, of, 202
- Case teaching, Cabot, Richard, 1
- Cells, blood, red, 624-625
 white, 625
- Cellular blood, normal values, 623
- Cerebellar artery, posterior inferior, 539
 occlusion of, signs and symptoms of, 539
- ataxia, 575
 gait in, 548
 signs of, 610
- Cerebello pontine angle tumor, 576, 609
- Cerebral arteries, pain in, due to distension of, 82
 arterio sclerosis, 612
 mental state due to, 612
 birth palsy (Little's disease), 570
 hemorrhage, spinal fluid in, 658
 hemiplegia, due to, 567-568
- Cerebro spinal fluid, 654-658
 cells in, 655
 changes in, due to disease, 656-658
 examination of, 654-656

Cerebro spinal fluid—Cont'd

- Lange test in (colloidal gold test), 655
 656
 pressure, 654-655
 Queckenstedt test in, 655
 tests for:
 colloidal gold, 655-656
 Lange test, 655-656
 Queckenstedt test, 655
 in xanthochromia, 655
 Cervical rib, 275, 482-484
 anesthesia due to, 112
 examination of, by x ray, 688-689
Cestan-Chenais syndrome (or Raymond Cestan syndrome), 560
 Chancre in syphilis, 521, 527
 Chaneroid, 527
 Charcot-Leyden crystals in sputum, 640
 Charcot-Marie muscle atrophy, 543
 Charcot-Marie Tooth neural peroneal atrophy, 580
 Charcot's joint, 497
 in syphilis, 676
 triad, 586
 Chemical intoxication, eye, in, 257
 Chest, 277-278
 contour, 277
 deformities of, 278
 emphysematous, 278
 mobility of, 278
 phthisic, 277
 sounds, 170
 auscultation, origin of, 170
 transmission of, 170
 Cheyne-Stokes breathing, 174
 respiration, 134, 174
 Chiari's syndrome, 455
 Chickenpox, skin eruptions, vesicular, due to, 201
 Chills, 176
 Chlorides, in blood, 639
 normal value, 629
 Choked disk, retina, of, 821
 Cholecystitis, 466-467
 Cholelithiasis, 466-467
 Cholesterol, 636-637
 in atheromatosis, 637
 of blood, 636
 in jaundice, 637
 in lipid nephrosis, 626
 normal value of, 629
 serum, 214
 in thyroid disease, 637
 in xanthomatosis, 636
 Chorea, 541, 590
 Huntington's 590
 Sydenham's, 541, 590
 Clavostek's sign, 542, 588
 in tetany, 235
 Circulation, coronary, anatomy of, 801-805
 Cirrhosis of the liver, 469-470
 biliary, 470
 telangiectasia, due to, 193
 Claudication, intermittent, 516
 Claw hand, 507, 555
 Clubbed fingers, 179, 498-499, 510
 Hippocratic fingers, 498
 Clutton's joints in syphilis, 673
 Coarctation, of aorta, 387
 Coercidiodomycosis of the lungs, 429
 Cogwheel breathing, 400
 Cold, common, 405
 Cole, Warren E., on gallbladder dye, 774
 Colitis, mucous, pain in, 103
 ulcerative:
 chronic, 480
 proctosigmoidoscopy in, 836
 x ray examination of, 768-769
 Colloidal gold test for cerebrospinal fluid, 655-656
 Colon, carcinoma of, 463
 examination of, by x-ray, 771-772
 examination of, by x-ray, 765-768
 polyposis of, examination of, by x-ray, 771
 tumor, benign of, examination of, by x-ray, 771
 Color index of blood, determination of, 627
 Coma, causes of, 145-146
 diagnostic procedures in, 147
 internal hemorrhages due to, 146
 Common cold, 405
 Congenital anomalies, examination of, by x-ray, 688-689
 Conjunctivitis, types of, 258
 Constipation:
 atonic, 773
 examination of, by x ray, 772-773
 significance of, 122
 spastic, 773
 Constitution, 183
 Constitutional inadequacy, 186
 asthenic syndrome in, 189
 linear physique in, 187
 Consumption, galloping, 415
 Contractions, premature, 309-311
 shown by electrocardiogram, 785
 Contracture, Dupuytren's, 505-506
 Volkmann's, 505
 Convulsions, 541, 591-595
 causes of, 148-150
 diagnosis, differential, 151
 due to eclampsia, 594
 Cornea, diseases of, 261
 Coronary artery:
 circulation, anatomy of, 801-805
 diseases of:
 diagnosis, differential, 374-375
 occlusion, 368-370
 patterns of, shown by electrocardiogram, 810-811
 prognosis, 375-376
 thrombosis, J. B. Herrick on, 802
 Cor pulmonale, 376-377
 Corrigan pulse, 313
 Cortical anesthesia, 605
 Costen's syndrome, 736
 Cough, causes of, 142
 due to bronchogenic carcinoma, 142
 Cramp, writer's, 589
 Creatinine, in blood, 632
 normal value of, 629
 Cremasteric reflex, 537
 Cretinism, 212
 Crisis, Dietl's, 465
 gastric, 574
 Cryptorchidism, 224
 Curschmann's spirals in sputum, 640

Cushing's syndrome, 223-224

Cyanosis, 135

causes of, 135

Cystic lungs, 424

Cysts:

branchiogenic, 275

of liver, 472

of spleen, 464

thyroglossal, 275

D

Dactylitis, syphilitic, 501

Dalrymple's sign, 260

Data, accumulation of, 52

judgment of, 52

omission of, 55

Decebel, unit of sound in auscultation, 166

Deficiency states, 181

Degeneration, hepatolenticular (Wilson's disease), 570-571

lenticular, progressive, 570-571

Delirium, 153

due to alcoholism, 153

due to barbiturates, 153

Deltoid paralysis, 487

Dercum's disease (*adiposis dolorosa*), 178, 506

Dermatitis, pellagra, in, 201

Dermatomyositis, 239

Diabetes:

bronze skin pigmentation due to, 204

insipidus, 237

melitus, 237

retinosis diabetic, 820

Diabetic gangrene, 517

Diagnosis, chances of success in, 73

differential, 50, 59

steps in, 6, 49

Diaphragm, 432-435

diseases of, 432-435

abscess, subphrenic, 433-434

hernia of, 435

x ray examination of, 727-730

examination of, by x-ray, 727-730

Diarrhea, causes of, 121

Dick test, for scarlet fever, 668

Dietl's crisis, 465

Digestive diseases, migraine in, 86

Digitalis in electrocardiograms, 802-803

Diphtheria, 252

of larynx, 825

myocardium, disease of, cause of, 379

Schick test for, 670

Diphtheritic polyneuritis, 562

Diseases:

Addison's (Thomas), anemia, 204, 244, 575

Aran-Duchenne, progressive muscular atrophy, 543, 579

Ayerza's (Abel), erythremia, 360

Banti's (Guido), anemia, 464

Bell's (Charles), palsy, 239

Bence-Jones, proteinuria, 620

Boeck's (Caesar P. M.), sarcoid, 193

Buerger's (Leo), thrombo angiitis obliterans, 518

Diseases—Cont'd

Charcot-Marie, progressive muscle atrophy, 543

Charcot Marie-Tooth, neural peroneal atrophy, 580

Dercum's (Francis X.), *adiposis dolorosa*, 178, 506

Duchenne Aran, progressive muscular atrophy, 543, 579

Duchenne Griesinger, pseudohypertrophic muscular dystrophy, 580

Dupuytren's (Guillaume), contracture, 505-506

Erb (Wilhelm), juvenile scapulohumeral atrophy, 579

paralysis, 570

Flint (Austin), heart murmur, 343

Friedreich's (Nickola) ataxia, 575

Gaucher's (Phillipe C. E.), of the spleen, 463

Gower (Wm. R.), muscular atrophy, 581

Hand Schüller Christian, endocrine gland disease, 203, 238

Henoch's (Edouard H.), purpura, 460

Hirschsprung's (Harold), congenital hypertrophic dilatation of colon, 455

Hodgkin's (Thomas), disease of lymph glands, 193, 271

Huntington's (George), chorea, 590

Jackson's (James), epilepsy, 594

Kienbock's (Robert), chronic progressive osteitis, 693

Krukenberg's (Friedrich), tumor, 462

Landouzy-Dejerine, facioscapulohumeral dystrophy, 543

Leyden-Moebius atrophy, 580

Little's (Wm. J.), cerebral birth palsy, 571

Ludwig's (Wm. F.), angina, 275

Marie's (Pierre), ataxia, 576

Meckel's (Johann F.), diverticulitis, 457

Menière's (Prosper), disease of semicircular canals, 155

Mikulicz's (Johann), disease of salivary glands, 254

Milroy's (W. F.), edema of legs, 487

Morvan's (Augustin M.), syringomyelia, 507

Niemann-Pick's, anemia of spleen and liver, 463

Oppenheim's (Hermann), amyotonia congenita, 582

Paget's (James), osteitis deformans, 179, 502-503, 686

Parkinson's (James), paralysis agitans, 585

Perthe's (Georg C.), osteochondritis deformans juvenilis, 503

Pick's (Filipp J.), atrophy of brain, 385-386

Quincke's (Heinrich I.), urticaria edematosa, 200

Raynaud's (Maurice), gangrene, 518

Schmorl's (Christian G.), of the lungs, 692

Schönlein's (Johann L.), purpura, 508

Simmond's (Morris), pituitary cachexia, 223

Sluder's (Greenfield), sphenopalatine neuralgia, 596

Diseases—Cont'd

- Still's (George F.), chronic polyarthritis, 487
- Sydenham's (Thomas), chorea, 541, 590
- Thomsen's (Asmus J.), myotonia congenita, 542, 586-587
- Volkmann's (Richard), contracture, 505
- Von Gierke's (Hans Paul), glycogenosis, 456
- Von Recklinghausen's (Friedrich D.), osteitis fibrosa cystica, 218
- Weber Christian's panniculitis, 506
- Well's (Adolf), disease of liver and spleen, 123
- Werdnig Hoffmann type of muscular atrophy, 580
- Wilson (Samuel), progressive lenticular degeneration, 570-571
- Disk, intervertebral, rupture of, 601
backache due to, 108
pain due to, 92
syndrome, 295
- Disseminated lupus erythematosus, 360
- Dittrick's plugs in sputum, 640
- Diverticulitis, examination by x-ray, 770
Meckel's, 457
of sigmoid, pain due to, 98
- Drowsiness, 148
- Drugs:
effect of, on electrocardiogram, 802
gum diseases due to, 245
hemorrhage, subcutaneous, due to, 193
intoxications, eye in, 257
multiple neuritis due to, 563
neuritis, multiple, due to, 563
skin eruptions due to, 196
granulomatous, due to, 196
vesicular, due to, 201
exfoliations due to, 199
- Duchenne Griesinger pseudohypertrophic muscular dystrophy, 580
- Ductus arteriosus, patent, 345
- Duodenal ulcer, examination of, by x ray, 761-763
pain due to, 96
- Dupuytren's contracture, 505-506
- Duroziez's sign, 314
- Dwarfism, hypothyroid, 213
- Dyschezia, 773
- Dysentery, proctosigmoidoscopy in, 836
amebic, 836
bacillary, 836
- Dyskinesia, 541, 582-586
- Dyspepsia, causes of, 119
- Dysphagia, causes of, 116
- Dyspnea, Biot's breathing in, 134
causes of, 130
Cheyne Stokes respiration in, 134
definition of, 124
hydrothorax due to, 134
nervous, 134
nocturnal, 133
paroxysmal, due to aortic syphilis, 131
- Dystrophia myotonica, 541, 581

Dystrophy:

- Duchenne Griesinger pseudohypertrophic muscular, 580
- Erb's progressive muscular, 543
- Landouzy Dejerine facioscapulohumeral, 543
- muscular progressive, of Erb, 543
- pseudohypertrophic muscular, of Duchenne-Griesinger, 580

E

- Ear, 265-266
hearing tests, 266
- Echinococcus disease, precipitin test for, 667
- Eclampsia, 594
convulsions due to, 594
- Ectomorphy, somatotypes, 184-185
- Ectopic pregnancy, 458
- Edeema:
angioneurotic, 200
causes of, 136-137
hypothyroidism, as cause of, 139
nephrosis, as cause of, 139
physiology of, 139
of skin, 206
physiological mechanism of, 206
- Effusion, pleural, pain due to, 90
- Electrocardiogram, 784-812
A-V prolonged conduction time, 798
artery, coronary, disease, in, 802-811
auricular extrasystoles, in, 788
fibrillation, in, 789-791
block, bundle branch, in, 798
interventricular, in, 798
bradycardia, in, 795-801
bundle branch block, in, 798
left, signs of, 801
right, signs of, 801
contractions, premature, 788
coronary disease, patterns in, 810-811
digitalis in, 802-803
drugs, effect of, on, 802
extrasystoles in, 789
heart block, 796
infarction, anterior wall, 811
posterior wall, 811
interpretation of, steps in, 784
intra auricular block, 799
intra-ventricular block, 799
nodal extrasystoles, 789
paroxysmal tachycardia, 792
rhythm, 801
paroxysmal tachycardia, 791
prolonged A-V conduction time, 798
quinidine in, 802, 804
sinus arrest in, 799
arrhythmia shown by, 788
bradycardia shown by, 795
tachycardia shown by, 791
tachycardia shown by, 791-795
ventricular extrasystoles, 789
left, strain, 811
paroxysmal tachycardia, 793
preponderance shown by, 788
right, strain, 812
- Elephantiasis, 487
- Ely test, 295

- Embolism, 510
 frequency of, 515
 pulmonary, pain due to, 91
 of superior mesenteric artery, pain due to, 103
- Emphysema of chest, 278
 of lungs, 426
- Empyema, 442
 examination by x ray, 723 724
 of lungs, 421-422
- Encephalitis, epidemic, 613
 spinal fluid in, 637
 post-, Parkinson's disease in, 585
 stupor due to, 613
- Encephalography, x-ray examination of, 783
- Endocarditis, 332-334
 petechia due to, 190
- Endocrine glands, diseases of:
 acromegaly, 239
 pituitary hyperfunction in, 215-216
 adenoma, parathyroid, due to, 218
 amenorrhea, 239
 basal metabolism in, 817
 cretinism, 212
 cryptorchidism in, 228
 Cushing's syndrome in, 223 224
 diabetes insipidus, 237
 mellitus, 237
 eunuchoid type of, 212
 eunuchoidism due to, 227
 examination, methods of, 208
 eye changes due to, 231
 frequency of, relative, 208
 in hair, 232 233
 hyperpituitarism, 214
 hypothyroidism in children, 212 213
 dwarfism due to, 213
 epiphyseal dysgenesis in, 214
 infantile type of, 212
 infantilism due to, 219
 menstruation disorders due to, 229
 metabolism, basal, in, 817
 muscular system in, tetany, 235
 tremor of hyperthyroidism, 234
 tremor of hypoglycemia, 236
 myxedema, 220 222
 obesity due to, 220
 pancreas, hyperinsulinism due to adenoma, 237
 parathyroid hyperfunction, osteitis fibrosa cystica (Von Recklinghausen's disease), 218
 pituitary deficiency in, *Simmond's disease*, 223
 relative frequency, 208
 skin in, 232
 Addison's disease, 232
 stature, influence on, 209, 211
 stocky type, 212
 tetany, 235
 Chvostek's sign in, 235
 Trousseau's sign in, 235
- Endomorphy, somatotypes, 184-185
- Epididymus, 530
- Epigastric hernia, 287
- Epilepsy, 591-593
 aura of, 591
 Jacksonian, 591
 types of, 150
- Epiphyseal dysgenesis in hypothyroidism, 214
- Epiphysis, examination by x-ray of, 685-688
- Equilibrium, 607-610
 disturbed by alcoholic intoxication, 608
- Erb's juvenile scapulohumeral atrophy, 579
 paralysis, 570
 progressive muscular dystrophy, 543
- Ergotism, 517
- Erythema, due to polycythemia vera, 196
 nodosum, 196, 508-509
- Erythromelalgia, 520
- Esophagoscopy, 834
- Esophagus, disease of, examination by x-ray, 736-745
 cardiospasm, 741-742
 diverticulum, 737
 foreign bodies in, 737
 stricture, 740
 tumors, 738 739
 ulcer, 744
 varices, 742-743
- Eunuchoidism, 227
- Ewald Boas test meal for gastric function, 642
- Exophthalmic goiter, 274
 in eye, orbit of, 259
 signs of, in, 260
 in head, 239
 tremor due to, 586
- Extrasystoles shown by electrocardiogram, 788, 789
 auricular, 788
 nodal, 789
 ventricular, 789
- Exudates, examination of, 659 661
- Eye:
 Argyll Robertson pupillary reactions, 264
 blood disease, in, 257
 changes in, in endocrine gland disease, 231
 chemical intoxications in, 257
 conjunctiva, diseases of, 258
 cornea, diseases of, 261
 drug intoxications in, 257
 examination of, 255
 exophthalmos, signs of, in, 260
 Dulrymple's, 260
 Joffroy's, 260
 Möbius', 260
 Stellwag's, 260
 Von Graefe's, 260
 infections of, 256
 iris, diseases of, 261-262
 pupil, regularity of, 262 263
 pupillary reactions, 264
 lids, diseases of, 257-258
 motor muscles, 259
 nervous system in, 257
 orbit, exophthalmus in, 259
 pupillary reactions, Argyll Robertson's, 264
 strain, headache due to, 83, 87
 vitamin deficiency in, 257
- F
- Face, disease, myasthenia gravis as, 241
- Facial hemihypertrophy, 578
 paralysis, 239, 538
- Facioscapulohumeral atrophy of Landouzy Dejerine, 579
 dystrophy of Landouzy-Dejerine, 543

- Fainting, 153
 Fallot, tetralogy of, 316
 Fascia, pain in, 79
 Fat pads, lipoma, 506
 subcutaneous, pain in, 79
 Fatigue, causes of, 114
 definition of, 113
 Febrile states, 305
 Fecal impaction, 478
 Feces, blood in, causes, 127
 Felty's syndrome, 463
 Femoral artery, aneurysm of, 521
 hernia, 289
 Fever, causes of, 175
 parrot, 429
 rheumatic, 490
 Rocky Mountain spotted, 191
 petechiae, due to, 191
 scarlet, skin eruptions in, 193
 typhoid, skin eruptions in, 193
 typhus, skin eruptions in, 193
 undulant, backache due to, 105
 Fibrillation, auricular, 312
 shown by electrocardiogram, 789 791
 Fiedler's myocarditis, 379 380
 Fingers, clubbed, 179, 498-499, 510
 Hippocratic fingers, 498, 510
 Flaccid paralysis, 538
 Flatulence, significance of, 122
 Flint, Austin, murmur in aortic regurgitation, 343
 Flutter, auricular, 306
 Foot drop, 507, 553
 Foramen ovale, patent, 341
 Fractional analysis of gastric contents, 644
 Fracture, march, 694
 Fragilitas ossium, 179
 Frei test, 528
 lymphogranuloma inguinale, 671
 Fremitus, vocal, 397
 Friction rub, 383, 436
 pericardial, 383
 pleural, 402, 436
 Friedrich's ataxia, 575
 Fröhlich's syndrome, 220

G

- Gait, 546-548
 ataxic, 546
 cerebellar, 548
 hemiplegic, spastic, 546
 Parkinsonian, 548
 spastic paraplegic, 546
 steppage, 546
 Gallbladder, 466-467
 diseases of, 122
 bile ducts, carcinoma of, jaundice due to, 122
 carcinoma of bile ducts, jaundice due to, 122
 gallstones, 466-467
 jaundice, obstructive, due to, 122
 drainage by duodenal tube, Lyon method of, 644
 dye in examination of, 774 776
 Cole, Warren E., on, 774
 Graham, Everts, on, 774
 Gallbladder—Cont'd
 examination of, by x ray, 774-778
 dye, use of, in, 774-776
 Lyon method of drainage, 644
 pain in, 96
 Mayo-Robson on, 96
 Murphy, John B., on, 96
 Galloping consumption, 415
 Gallstones, 122, 466-467
 Ganglion, 505
 Gangrene, 516 517
 diabetic, 517
 gas, 517
 Gastric contents, examination of, 642-644
 crisis, 574
 in tabes dorsalis, 100
 ulcer, malignant, examination of, by x-ray, 754
 Gastroscopy, 838
 Gaucher's disease of spleen, 463
 Geniculate ganglion neuralgia, 596
 German measles, skin eruptions in, 197
 Grant, Humbert's, 178
 Girdle pain, in tabes dorsalis, 92, 100
 Glanders, skin eruption, granulomatous, due to, 194
 Glands:
 adrenal, 224
 tumor of, adrenogenital, 224
 endocrine, diseases of:
 acromegaly, 239
 pituitary hyperfunction in, 215 216
 adenoma of parathyroid due to, 218
 amenorrhea, 230
 cretinism, 212
 cryptorchidism in, 228
 Cushing's syndrome in, 223-224
 diabetes insipidus due to, 237
 mellitus due to, 237
 eunuchoid type of, 212
 eunuchoidism due to, 227
 examination of, methods of, 208
 frequency of, relative, 209
 in hair, 232 233
 hypothyroidism, in children, 212 213
 dwarfism due to, 213
 epiphyseal dysgenesis in, 214
 infantilism type of, 212, 219
 menstruation disorders due to, 229
 muscular system in, 234
 hyperthyroidism 234
 tetany, 235
 tremor of hypoglycemia, 234 236
 myxedema, 220 223
 parathyroid hyperfunction, osteitis fibrosa cystica, (Von Recklinghausen's disease), 218
 pituitary deficiency, Simmond's disease, 223
 skin in, Addison's disease, 232
 stature, influence on, 209, 211
 stocky type, 212
 tetany, 235
 Chrostek's sign in, 235
 Trousseau's sign in, 235
 pituitary, diseases of:
 acromegaly, 215 216

Glands, pituitary, diseases of—Cont'd
 Cushing's syndrome in, 223-224
 diabetes insipidus in, 237
 hyperfunction, 214
 acromegaly in, 215-216
 Leonard Mark's description of, 214
 hyperpituitarism, 214
 insufficiency of, Simmond's disease, 214, 223
 Simmond's disease, pituitary insufficiency, 223
 salivary, diseases of, 233-255, 270
 in infectious diseases, 253
 Mikulicz's disease of, 254
 in mumps, 253
 in parotitis, 253
 postoperative, 253
 sialolithiasis, 255
 ureoparotitis, 254
 thyroid:
 diseases of:
 basal metabolism in, 816-817
 cholesterol in, 637
 edema due to hypothyroidism, 138
 exophthalmic goiter, 274
 in head, diseases of, 239
 goiter, diffuse, toxic, 274
 nontoxic, 274
 exophthalmic, 274
 tremor due to, 586
 nodular, nontoxic, 274
 toxic, 274
 nontoxic, diffuse, 274
 nodular, 274
 toxic, diffuse, 274
 nodular, 274
 hypothyroidism, in children, 212-213
 dwarfism due to, 213
 edema due to, 138
 epiphyseal dysgenesis in, 214
 myxedema, 221-223
 swelling of, 273-274
 metabolism, basal in, 816-817
 Globulin, blood, normal value of, 622
 serum, in blood, 638
 Glomus, 521
 Glucose tolerance test, 632-633
 Glycosuria, causes of, 620
 Goiter:
 exophthalmic, 274
 eye, orbit of, in, 259
 in head diseases, 239
 tremor due to, 586
 fetal adenoma, 274
 nontoxic diffuse, 274
 nodular, 274
 toxic diffuse, 274
 nodular, 274
 Gold test, colloidal, for cerebrospinal fluid, 655-656
 Goldthwait's sign, 294
 Gonorrhea, in arthritis, 491-492
 Gout, 493-496
 examination of, by x ray, 686
 tophi in, 493, 496
 uric acid in, 493
 Gower's muscular atrophy, 581
 Graham, Everts, gallbladder dye, on, 774
 Groin, lymph node enlargement, 289-291

Growing pains, 490
 Growth, basic types, 210-211
 eunuchoid, 212
 infantilism, 212
 normal, 211
 stocky, 212
 Guillain-Barre syndrome, 562
 Gumma, pain due to, 92
 skin eruptions, granulomatous due to, 193
 Gums, diseases of, 244-245
 due to blood diseases, 245
 due to deficiency diseases, 245
 due to drugs, 245
 due to Vincent's infection, 244

H

Hair, effect of endocrine diseases on, 232-233
 Hand, claw, 507, 555
 clonus reflex, 536
 Hand-Schüller-Christian disease, 203
 Haygarth's nodosities, 508
 Hand and Rivers, pain, investigation of, 79
 Head, diseases of, 238-241
 achondroplasia, 238
 acromegaly, 239
 adenoids, 239
 Bell's palsy, 239
 dermatomyositis, 239
 exophthalmic goiter, 239
 facial paralysis, 239
 fibrocystic bone disease, 238
 goiter, exophthalmic, 239
 Hand-Schüller-Christian disease, 238
 hydrocephalus, 238
 leontiasis osses, 238
 microcephaly, 238
 mitral stenosis, 239
 myasthenia gravis, 241
 osteogenesis imperfecta, 238
 oxycephaly, 238
 palsy, Bell's, 239
 stenosis, mitral, 239
 Headache:
 due to brain tumor, 89
 chronic, 83
 due to eye strain, 83, 87
 due to hypertension, 89
 indurative, 88
 infections, pain in, 83
 lower face (sphenopalatine neuralgia—Sluder's disease), 596
 mechanism of, 83
 migraine, 83
 "sick headache," 86
 due to nasal obstruction, 88
 of nasal origin, 88
 neuralgia, Sluder's, 89
 due to neurosis, 83
 neurotic, 86
 otitis media, due to, 89
 reflex, pain in, 83
 sinusitis, 88
 Sluder's neuralgia, 89
 sphenopalatine (lower face), 596
 due to syphilis, 89
 tic douloureux, due to, 89
 toxic, pain in, 83
 trigeminal neuralgia, 89

Hearing tests, 266

Heart:

A-V conduction time, prolonged, shown by electrocardiogram, 798

circulation, coronary, anatomy of, 804 805

coronary circulation, anatomy of, 804 805

diseases of:

angina pectoris, 139, 366-367

diagnosis, differential, of, 140

aorta, of, 387-391

aneurysm, 392-393

dissecting, 387

rupture, of, 393-394

aortitis, 390-391

arteriosclerosis, 388-389

atheroma, 388-389

coarctation of, 387

congenital, 345

occlusion, 387

regurgitation, Austin Flint's murmur in, 343

sclerosis, arterio-, 388-389

stenosis, 343-344

aortic, 313-314

syphilitic of, 389-394

valve disease, 341

arrhythmia, shown by electrocardiogram, 788

asthma in, 133

auricular fibrillation, 312

shown by electrocardiogram, 789-791

extrasystoles, shown by electrocardiogram, 788

block, bundle branch, shown by electrocardiogram, 798

left, signs of, shown by electrocardiogram, 801

right, signs of, shown by electrocardiogram, 801

intra auricular, shown by electrocardiogram, 798

intraventricular, shown by electrocardiogram, 798

shown by electrocardiogram, 796

bradycardia, Adams-Stokes syndrome, 306-307

bundle branch block, 309

due to heart block, 306-307

shown by electrocardiogram, 795-801

sinus, shown by electrocardiogram, 795

bundle branch block, shown by electrocardiogram, 798

left, signs of, shown by electrocardiogram, 801

right, signs of, shown by electrocardiogram, 801

classification of, 361

congenital, 344-347

aorta, coarctation of, 345

clubbed fingers due to, 494-499

coarctation of aorta, 345

ductus arteriosus, patent, 345

foramen ovale, patent, 346

patent ductus arteriosus, 345

foramen ovale, 346

pulmonary stenosis, 346

septal defects, ventricular, 346

stenosis, pulmonary, 346

Heart, diseases of, congenital—Cont'd

tetralogy of Fallot, 346

ventricle septal defects, 346

congestive failure, etiology of, 363

pathologic physiology of, 363, 365

signs of, 361-362

contractions, premature, shown by electrocardiogram, 788

coronary arteries, diseases of, 368-376

diagnosis, differential, 374-375

occlusion, 368-370

patterns of, shown by electrocardiogram, 810-811

prognosis, 375-376

thrombosis, J. B. Herrick on, 802

extrasystoles, 309, 311

shown by electrocardiogram, 788-789

auricular, 788

nodal, 789

fibrillation, auricular, shown by electrocardiogram, 789-791

gallon, 324-325

incidence of, 298

infarction, anterior wall, shown by electrocardiogram, 811

posterior wall, shown by electrocardiogram, 811

intra-auricular block, shown by electrocardiogram, 798

murmurs, due to endocarditis, 332-334

interpretation of, 330-332

functional or organic, 332

point of maximum loudness, 330

quality of, 331

timing of, 330

mitral valve disease, 334-336

myocardium, diseases of, 376

aneurysm, 380

due to beri beri, 381

calcification of, 380

cor pulmonale, 376-377

due to diphtheria, 379

Fiedler's myocarditis, 379-380

due to myxedema, 381

rheumatic, 378

syphilitic, 379

thyrotoxicosis, 381

nodal extrasystoles, shown by electrocardiogram, 789

paroxysmal tachycardia, shown by electrocardiogram, 792

rhythm, shown by electrocardiogram, 801

pains in, 371

palpitation of, causes of, 138-139

pericardium, 382-384

acute pericarditis, 382

chronic adhesive pericarditis, 383

effusion, 383-384

Pick's disease, 385-386

polyserositis, 386

premature contractions, 309-311

pulmonary valve, 340

pulse, 313-314

capillary pulse, 314

Corrigan pulse, 313

Duroziez's sign, 314

waterhammer pulse, 313

Heart, diseases of—Cont'd

- pulsus alternans, 312
- sinus arrest, shown by electrocardiogram, 793
 - arrhythmia, 309-310
 - shown by electrocardiogram, 788
 - bradycardia, shown by electrocardiogram, 792
 - tachycardia, shown by electrocardiogram, 791
- tachycardia, 305-306
 - asthenia, neurocirculatory, 306
 - auricular flutter, 306
 - febrile states in, 303
 - neurocirculatory asthenia, 306
 - nodal paroxysmal, shown by electrocardiogram, 792
 - paroxysmal, 306
 - shown by electrocardiogram, 791
 - sinus, shown by electrocardiogram, 791
 - thyroid intoxication of, 305
 - ventricular, 306
 - paroxysmal, shown by electrocardiogram, 793
- thrombosis, coronary, J. B. Herrick on, 802
- tricuspid valve disease, 339-340
- valve, mitral, 334-336
 - pulmonary, 340
 - tricuspid, 339-340
- ventricular extrasystoles, shown by electrocardiogram, 789
 - paroxysmal tachycardia, shown by electrocardiogram, 793
 - preponderance, shown by electrocardiogram, 788
 - strain, left, shown by electrocardiogram, 811
 - right, shown by electrocardiogram, 812
- displacement of, by pleural fluids, 722
- examination of, 300-304
 - methods of inspection, 301-304
 - auscultation, 318-321
 - palpation, 314-316
 - of apex beat, 316
 - of pulse, 304
 - of thrills, 317
 - percussion, 318
 - by x-ray, 695-701
- measurements of, examination of, by x-ray, 700-701
- rhythm of, 321-325
 - nodal, shown by electrocardiogram, 801
- shadows, examination of, by x-ray, 696
- sounds, 328-330, 332-334
 - differentiation of, 326-327
- Stokes Adams syndrome, 796
- x-ray examination of, 695-701
- Heberden's nodes, 490, 508-509
- Height, standards, 176
- Hematemesis, causes of, 119
- Hematoma, subdural, stupor due to, 615
 - of spleen, 464
- Hematuria, causes of, 128
- Hemihypertrophy, facial, 578
- Hemiplegia, 566
 - due to brain tumor, 568
 - due to cerebral hemorrhage, 567-568
 - diagnosis, differential, of, 569
 - gait in, 546
 - due to syphilis, 568
 - due to tumor of brain, 568
- Hemochromatosis, 470
 - skin pigmentation due to, 204
- Hemoglobinuria, paroxysmal, 617
- Hemophilia, 496
 - of joints, 496
- Hemoptysis, causes of, 143
- Hemorrhage, arachnoid, stupor due to, 615
 - cerebral, spinal fluid in, 658
 - due to hemiplegia, 567-568
 - internal, 460
 - coma due to, 146
 - skin, 190
 - petechia, 190
 - subcutaneous, due to drugs, 193
 - due to leucemia, 192
 - due to scurvy, 192
- Hemorrhoids, 532
- Henoch's purpura, 460
- Hepatoleenticular degeneration (Wilson's disease), 570-571
- Hepatomegaly, 468
- Hernia, diaphragmatic, 435
 - examination of, by x-ray, 728-729
 - examination for, 297
 - inguinal, strangulated, 459
 - types of, 287, 289
 - diaphragmatic, 435
 - epigastric, 287
 - femoral, 289
 - incisional, 289
 - inguinal, 289
 - lumbar, 289
 - ventral, 289
- Herniation of nucleus pulposus, 601
- Herpes zoster, 598
 - pain in, 91
 - skin eruption due to, 200
 - vesicular, due to, 202
- Herrick, J. B., on coronary thrombosis, 802
- Hertzler, Arthur E., on chronic appendicitis, 15
- Hippocratic breathing, 174
 - ingers, 498, 510
- Hippuric acid, synthesis test, 650
- Hirschsprung's disease, 453
 - examination of, by x-ray, 766-768
- Histoplasmosis, 464
- History, of pain, 78
 - routine outline of, 77
- Hoarseness, causes of, 144
- Hodgkin's disease, 193
 - in lymph nodes, 271
- Horner's syndrome, 551-552
- Humbert, Dr. C. D., 178
- Humbert's giant's, 178
- Huntington's chorea, 590
- Hutchinson's teeth, 246
 - triad, 824
- Hydrarthrosis, intermittent, 497
- Hydrocele, 529
- Hydrocephalus, in diseases of head, 238
- Hydronephrosis, x-ray examination of, 779

- Hydrothorax, 442
 dyspnea due to, 134
 Hyperalgesic areas in viscera, 94
 Hyperchlorhydria, 644
 Hyperinsulinism, due to adenoma, 237
 Hyperparathyroidism, osteitis fibrosa cystica
 (Von Recklinghausen's disease), 218
 examination of, by x-ray, 686-687
 Hyperpituitarism, 214
 Hypertension, 353-354
 in childhood, 357
 essential, 358
 forms of, 357
 headache due to, 89
 incidence of, 355-356
 Hypertrophia musculorum vera, 580
 Hypochlorhydria, 644
 Hypoglycemia, tremor of, in endocrine gland
 disease of muscular system,
 236
 Hypothyroidism, in children, 212-213
 dwarfism due to, 213
 edema due to, 138
 epiphyseal dysgenesis in, 214
 myxedema in, 220-222
 Hysteria, anesthesia due to, 113, 605
 dyspnea, nervous, 134

I

- Icterus index test, 649
 Idiopathic purpura, 192
 Ileitis, regional, 475
 examination of, by x ray, 764-765
 Ileus, paralytic, 458
 Immunologic tests, 662-671
 Impaction, fecal, 478
 Incisional hernia, 289
 Incontinence, urinary, causes of, 128
 Indigestion, causes of, 119
 Infantile paralysis, 560
 Infantilism, 212
 causes of, 219
 Infarction, anterior wall, shown by electro
 cardiogram, 811
 posterior wall, shown by electrocardio
 gram, 811
 Infectious diseases, skin eruptions in, 197
 Influenza, 405
 Inguinal hernia, 289
 Insane, paralysis of, paretic, 595, 612
 Insomnia, 152
 due to neurosis, 152
 Inspection, of heart, 301-304
 in physical examination, 158
 slit lamp in, 158-159
 transillumination in, 159
 Intention tremor, 541
 Intercoastal neuralgia, 597
 Intermittent claudication, 516
 hydrarthrosis, 497
 Intestines, examination of, by x ray, 761-774
 obstruction, 457
 acute, causes of, 126
 tuberculosis of, 417
 examination of, by x ray, 769
 Involuntary reactions, 182

- Iodine, in blood, 637
 normal value of, 629
 Iris, 261-262
 pupillary reaction, 264
 regularity of pupil, 262-263

J

- Jackson's epilepsy, 594
 syndrome, 557
 Jacob syndrome, 586
 Jake paralysis (Jamaica ginger paralysis),
 564
 Jamaica ginger paralysis, 564
 Jaundice, 122-126
 acute catarrhal, 123
 yellow atrophy of liver, due to, 124
 due to carcinoma of bile ducts, 122
 cholesterol in, 637
 hematogenous, 124
 incidence of, 126
 infectious, 122
 obstructive, due to gallstones, 122
 due to Weil's disease, 123
 Jaw jerk reflex, 534
 Joffroy's sign, 260
 Joint, Charcot's, 497
 hemophilia of, 496
 Jostes, Frederick J., outline of examination
 of the spine, 294
 Juvenile scapulohumeral atrophy of Erb, 579

K

- Keratosis, of skin, 209
 Kidney, Brewer's, 462
 functional test, 650-653
 normal values, 622
 hydronephrosis, x ray examination of, 779
 pelvis of, pain in, 80
 phenolsulfonephthalein test for, 652
 stone, x ray examination for, 778
 test, functional, 650-653
 phenolsulfonephthalein, 652
 urea clearance, 652
 tumors of, x-ray examination of, 780-781
 urea clearance test, 652
 x-ray examination of, 778-781
 Kienboch's disease, 693
 Knee jerk reflex, 536
 Koplik's spots in mouth in measles, 244
 Korsakoff's syndrome, 563
 Kraurosis vulvae, 524
 Krukenberg tumor, 462
 Kyphosis, backache due to, 107

L

- Laennec, Rene T. H., auscultation, descrip
 tion of, 169
 Landouzy-Dejerine, facioscapulohumeral at
 rophy, 579
 dystrophy, 643
 Lange test, in cerebrospinal fluid, 655-656
 Laryngitis, acute infectious, 825
 Laryngoscopy, 825-830

- Larynx, diseases of, 825-830
 diphtheria of, 825
 edema of, 825
 hoarseness of, 144
 laryngitis, acute, 825
 paralysis of, 829-830
 syphilis of, 829
 tuberculosis of, 825-828
 tumors of, 829
- Lasègue's sign, 294
- Lead colic, pain due to, 103
 neuritis, 564
- Leg, atrophy of, 186
- Legs, paraplegia, spastic, of, 569
- Lennander's experiments in abdominal pain, 92
 in visceral pain, 79
- Lenticular degeneration, progressive, 570-571
- Leontiasis ossea, 238
- Leprosy, anesthesia in, 603
 skin eruptions, granulomatous, due to, 195
- Leucemia, hemorrhage, subcutaneous in, 192
- Leucoctosis, 626
- Leuconychia, 509
- Leucopenia of blood, 627
- Leucoplakia in mouth diseases, 249
- Lewin's sign, 294
- Leyden-Moebius atrophy, 580
- Lipodystrophia progressiva, 179
- Lipoid nephrosis, cholesterol in, 636
- Lipoma, 506
- Lips, diseases of, 242
 ariboflavinosis, 243
 riboflavin deficiency, in, 243
 vitamin deficiency in, 243
- Lithiasis (stone) in pancreas, 473
- Litten's sign, 279
- Little's disease, 570
- Livedo reticularis, 519
- Liver:
 diseases of:
 abscess, 472
 atrophy, yellow, acute, 459
 jaundice due to, 124
 cirrhosis, 469-470
 biliary, 470
 telangiectasis due to, 193
 cysts, 472
 enlargement, causes of, 468
 hepatomegaly, cause of enlargement, 468
 syphilis, 471
 tumors, 472
 Van den Bergh reaction, 649
- tests:
 azorubins, 650
 bilirubin excretion test, 649
 bromsulfalein, 650
 carbohydrate function test, 649-650
 functional, normal values, 647-648
 hippuric acid synthesis, 650
 icterus index test, 649
 rose bengal test, 650
- Lobar pneumonia, 419-420
- Locomotor ataxia, 571
- Lordosis, backache due to, 107
- Ludwig's angina, 275
- Lumbago, backache due to, 109
- Lumbar hernia, 289
- Lungs, diseases of, 412-419
 abscess, 423, 425
 examination of, by x-ray, 714
 actinomycosis, 428
 atelectasis, 427
 blastomycosis, 429
 bronchiogenic carcinoma, 424
 bronchopneumonia, 420
 carcinoma, bronchiogenic, 424
 coccidioidomycosis, 429
 collapse, massive, 428
 cough, causes of, 142
 due to bronchiogenic carcinoma, 142
 cyst of, 424
 examination of, by x-ray, 715
 emphysema, 426
 empyema, 421-422, 442
 hemoptysis, causes of, 143
 hydrothorax, 442
 lobar pneumonia, 419-420
 massive collapse, 428
 mycotic disease of, 428-429
 neoplasms, 424
 osteoarthropathy, pulmonary, 497
 parrot fever, 429
 pneumonia, 419-423
 bronchial, 420
 lobar, 419-420
 virus, 421
 pneumonococcosis, 426
 examination of, by x-ray, 714-715
 pneumothorax, spontaneous, 443
 psittacosis, 429
 pulmonary osteoarthropathy, 497
 spontaneous pneumothorax, 443
 sporotrichosis, 429
 syphilis of, 423
 examination of, by x-ray, 713-714
 tuberculosis of, 412-417
 in childhood, 414
 diagnosis, differential of, 417
 galloping consumption, 415
 intestinal, 417
 Mantoux' test for, 669
 military, 414
 patch test for, 670
 pneumothorax, spontaneous, 447
 skin test for, 668-669
 spontaneous pneumothorax of, 417
 tests:
 Mantoux, 669
 patch, 670
 skin, 668-669
 Von Pirquet's, 669
 tuberculin for, 669
 Von Pirquet's test for, 669
 tularemia, 429
 tumors:
 bronchiogenic carcinoma, 424
 virus pneumonia, 421
- Lupus erythematosus, disseminated, 360
 skin eruptions, granulomatous, in, 360
- Lymph nodes, 271
 enlargement of, 506
 in groin, 289-291
 Hodgkin's disease in, 271
 syphilis in, 271
 tuberculosis in, 271

- Lymphocytosis of blood, 627
 Lymphogranuloma inguinale, *Fras's test*, 671
 venereum, 524, 528
 Lymphoma, 462
 Lymphosarcoma, 271
 Lyon method of gallbladder drainage by duodenal tube, 614
- M
- Mackenzie's theory of visceral pain, 93
 Malocclusion of teeth, 216
 Mantoux test for tuberculosis, 669
 March fracture, 694
 Marie's ataxia, 576
 Mark's, Leonard, description of pituitary hyperfunction in acromegaly, 216
 Mastitis of breast, 292
 Mayo Robson point, 448
 McBurney, Charles, diagnostic point in acute appendicitis, 96, 448
 Measles, 197
 German, skin eruptions in, 197
 Koplik's spots in mouth in, 244
 skin eruptions in, 197
 Meckel's diverticulitis, 457
 Median paralysis, 540
 Mediastinum, diseases of, 430 432, 725
 examination of, by x ray, 725-727
 Melena, causes of, 127
 Ménière's disease, vertigo in, 155
 syndrome, 609
 Meningismus, 542
 Meningitides, acute, spinal fluid in, 656
 Meningitis, 190
 acute, spinal fluid in, 657
 chronic, neuralgia due to, 599
 petechiae due to, 190
 stupor due to, 614
 tuberculous, spinal fluid in, 656
 Menstruation disorders due to endocrine diseases, 229
 Mental states, 610 616
 due to brain tumors, 610 611
 due to cerebral arteriosclerosis, 612
 examination for, 548 549
 Meralgia paresthetica, 602
 Mesenteric thrombosis, 458
 Mesentery, pain in, 80
 Mesomorphy, somatotypes, 181-185
 Metabolism, 813 817
 determination of, method of, 813 814
 diseases of, 815 816
 in children, 214
 endocrine, 817
 thyroid, 816-817
 normal value of, 815
 Methemoglobinemia, skin discoloration due to, 203
 Microcephaly, in diseases of the head, 239
 Migraine, 81-86
 aura in, 85
 motor, 86
 sensory, 85
 causes of, 84
 diagnosis of, 84
 in digestive disturbances, 86
 " sick headache," 86
 Minkiewicz's disease, 254
 Miliary tuberculosis, 414
 Millard Gubler Foville syndrome, 558
 Milroy's disease, 487
 Mitral regurgitation, 334 338
 Graham Steell murmur in, 338
 stenosis, 334 338
 in diseases of the head, 239
 Mobius's sign, 260
 Morley, John, monograph on abdominal pain, 94
 Morvan's disease, 507
 Mouth, 244-251
 Addison's disease, 244
 agranulocytic angina, 249
 caries of teeth, 248
 examination of, 241
 gums, diseases of, 245
 Vincent's infection, 244
 Koplik's spots in measles, 244
 leucoplakia, 249
 mucous patches in, 244
 stomatitis, 249
 tongue, diseases of, 250 251
 toncillitis, 251
 Moynihan, Berkeley, on peptic ulcer, 96
 on pain in peptic ulcer, 96
 Mucous membrane, pain in, 79
 patches in mouth disease, 243
 Multiple neuritis, 563
 due to drugs, 563
 due to vitamin deficiency, 563
 Multiple sclerosis, 586, 604
 spastic paralysis due to, 569
 spinal fluid in, 638
 Murmurs, heart, 328 330, 332 334
 Murphy, John B., on gallbladder pain, 96
 Murphy's sign, 448
 Muscles, 503 504
 atrophy, Gower's 591
 progressive, 180
 of Aran Duchenne, 579
 of Charcot-Marie type, 543
 of Werdnig-Hoffman type, 543
 dermatomyositis, 504
 dystrophy, 543, 580
 progressive, Erb's
 pseudohypertrophic, of Duchenne-Griesinger, 580
 myositis ossificans, 503 504
 of neck, 276
 pain in, 79
 torticollis, 276
 spasms, 542
 spiral paralysis, 579
 Musculospiral paralysis, 579
 Myasthenia gravis, 241, 547, 578
 Mycotic aneurysm, 325
 disease of the lungs, 429 429
 Myelitis, neuralgia due to, 599
 Myelography, examination of, by x ray, 783
 Myeloma, examination of, by x ray, 693
 Myelomalacia, 563
 Myocardium, 391
 diseases of, 376, 391
 aneurysm, 390
 due to beri beri, 381
 calcification of, 390

Myocardium, diseases of—Cont'd

- corpulmonale, 376-377
- due to diphtheria, 379
- Fiedler's myocarditis, 379-380
- due to myxedema, 381
- rheumatic, 378
- sypilis of, 379
- due to thyrotoxicosis, 381
- Myopathies, 576-582
- Myositis ossificans, 502-504
- examination of, by x-ray, 695
- Myotonia, 542
- congenita, 582
- of Oppenheim, 544
- Thomson's disease, 542, 586-587
- Myotonia, dystrophica, 544
- Myxedema, 220-222
- edema due to, hypothyroidism, 138
- myocardium disease due to, 381

N

- Nails, diseases of, 509-510
- Nasal obstruction, headache due to, 88
- Nausea, causes of, 115-116
- Neck, 267-268
- muscle disorders of, 276
- torticollis, 276
- pain in, 92
- pulsations of, 267
- due to aneurysm, 267
- due to aortic regurgitation, 267
- swellings of, classification of, 267-268
- due to actinomycosis, 268
- anthrax, 268
- branchiogenic cysts, 275
- carotid tumor, 275
- cervical rib, 275
- Ludwig's angina, 275
- lymph nodes, 271
- lymphosarcoma, 271
- salivary glands, 270
- thyroglossal cyst, 275
- thyroid gland, 273-274
- Neoplasms, of lungs, 424
- Nephritis, polyuria due to, 127
- Nephrolithiasis, 778
- Nephrosis, edema due to, 138
- Nerve injury, anesthesia due to, 112
- Nerves, diseases of, 507-508
- Nervous system, eyes in, 257
- central, x-ray examination of, 783
- encephalography, 783
- myelography, 783
- ventriculography, 783
- Nervousness, 155
- Neural peroneal atrophy of Charcot Marie-Tooth, 580
- Neuralgia, 595-597
- due to chronic meningitis, 599
- geniculate ganglion, 596
- intercostal, 597
- Carnett, John Burton on, 100
- pain due to, 100
- due to myelitis, 599
- sciatic, 600
- Sluder's, 89, 596
- sphenopalatine (lower face, Sluder's), 596

Neuralgia—Cont'd

- due to spinal cord tumor, 597
- due to spondylitis, 599
- due to syringomyelia, 599
- tic douloureux, 595-596
- trifacial (tic douloureux), 595-596
- trigeminal, headache due to, 89
- Neuritis, 562-564
- alcoholic, 563
- arsenical, 564
- branchial, 597
- lead, 564
- multiple, 562-563
- due to drugs, 563
- due to vitamin deficiency, 563
- polyneuritis, diphtheritic, 562
- infectious, Guillain Barré syndrome, 562
- Neurocirculatory asthenia, 306
- Neuronitis, 556, 562
- Neurosis, headache due to, 110
- headache due to, 83
- insomnia due to, 152
- Neurosyphilis, late, spinal fluid in, 637
- Neurotic headache, 86
- Niche, in peptic ulcer, 752
- Niemann-Pick's disease, of spleen, 463
- Nipple, diseases of, 284
- Nocturia, 618
- Nodal extrasystoles, shown by electrocardiogram, 789
- rhythm, shown by electrocardiogram, 801
- Nodes, Heberden's, 490, 508-509
- lymph, 271
- enlarged, 506
- in groin, 289-291
- Hodgkin's disease in, 271
- Osler's, 509
- sypilis in, 271
- tuberculosis in, 271
- Virchow's, 462
- Nodosities, Haygarth's, 508
- Nodules, rheumatic of skin, 196
- Nonprotein nitrogen, 631
- Normal values:
- basal metabolism, 815
- blood, 622-623
- albumin, 622
- bleeding time, 623
- cellular, 623
- chemical, 622
- chemistry, 629
- calcium, 629
- carbon dioxide, 629
- chlorides, 629
- cholesterol, 629
- creatinine, 629
- glucose tolerance, 629
- iodine, 629
- nitrogen, 629
- nonprotein, 629
- phosphatase, 629
- phosphorus, 629
- potassium, 629
- proteins, 629
- sodium, 629
- sugar, 629
- urea, 629
- uric acid, 629

Normal values, blood—Cont'd

- coagulating time, 623
- fragility, 623
- globulin, 622
- prothrombin, 622
- sedimentation rate, 623
- kidney function test, 622
- metabolism, basal, 815
- renal function test, 622
- urine, 621
- Nose, 266
 - obstruction of, headache due to, 88
- Nothnagel's syndrome, 500
- Nucleus pulposus, 108, 601, 692
 - examination of, by x-ray, 602
 - herniation of, 601
 - rupture of, backache due to, 109
- Nutrition, 179
- Nystagmus, 542, 595

O

- Ober test, 295
- Obesity, 179-180
 - due to glandular dysfunctions, 220
 - types of, 219
- Occlusion, 357
- Ochronosis, skin eruptions due to, 205
- Oculomotor paralysis, 538
- Ophthalmoscopy, 818-823
 - retina examination of, by, 818-819
- Opisthotonos, 542
- Oppenheim's disease, 582
 - myotonia congenita, 511
- Orthopnea, definition of, 131
 - due to diminished vital capacity, 132
- Orthostatic albuminuria, 619
- Oster's nodes, 509
- Ossification, delayed, stature, effect on, 209
- Osteitis deformans, 179
 - Paget's disease, 502-503
 - fibrosa cystica (hyperparathyroidism), 686-687
 - examination of, by x ray, 686-687
 - Von Recklinghausen's disease, 218
- Osteoarthritis, 490
- Osteoarthropathy, pulmonary, 497
- Osteogenesis imperfecta, in head diseases, 238
- Osteomalacia, 179, 502
 - in pregnancy, 502
 - due to vitamin deficiency, 502
- Osteomyelitis, 500
 - examination of, by x ray, 679-680
 - of spine, backache due to, 105
- Osteoporosis, postmenstrual, 217
- Otitis media, acute, 823
 - chronic, 821
 - headache due to, 89
- Otosclerosis, 824
- Otology, 823-824
- Ovary, 224, 458
 - arrhenoblastomata, tumor of, 224
 - tumor of, with twisted pedicle, 454
- Oxycephaly, in head diseases, 228

P

- Paget's disease, 179
 - backache due to, 107
 - examination of, by x ray, 686
- Pain, abdominal, 92
 - due to allergy, 103
 - frequency of, 99
 - Lennander's experiments on, 92
 - Morley, John, monograph on, 94
 - referred, 98
 - activity, influence of, on, 83
- acute pancreatitis, 97
 - due to aneurysm, 91
 - due to aortitis, 91
 - due to appendicitis, 96
 - in arm, 92
 - bladder, urinary, 90
 - in bones, 79
 - in brain, 81
 - due to cerebral artery distention, 82
 - due to disk, ruptured, 92
 - due to distention of cerebral arteries, 82
 - due to diverticulitis of sigmoid, 98
 - due to duodenal ulcer, 96
 - due to embolism of superior mesenteric artery, 103
- fascia, 79
 - due to gallbladder disease, 96
 - Mayo-Robson on, 96
 - Murphy, John B., on, 96
- due to gastric crisis of tabes dorsalis, 100
- ulcer, 96
- girdle pain in tabes dorsalis, 91, 100
- growing, 490
- due to gonorrhea, 92
- Head and Rivers, investigations of, 79
- in headache, 83
 - reflex, 83
 - toxic, 83
- in herpes zoster, 91
- history of, 78
- individual sensitivity to, 83
- influence of activity on, 83
 - position on, 83
- due to intercostal neuralgia, 100
- in kidney, pelvis of, 80
- lancinating, in tabes dorsalis, 100
- due to lead colic, 103
- in legs, 110
- lightning, in tabes dorsalis, 110
- McBurney's point in, 96
- in mesentery, 80
- due to mucous colitis, 103
- in mucous membrane, 79
- in muscles, 79
- in neck, 92
- due to neuralgia, intercostal, 100
- due to pancreatitis, acute, 99
- in peptic ulcer, Berkeley Moynihan on, 90
- pericardial, 90
 - Capp's experiments in, 79
 - personality of patient in, 83
 - in pleura, Capp's experiments on, 79
 - due to pleural effusion, 90
 - due to pleurisy, 90
 - due to pneumothorax, 91
 - position, influence of, on, 83
 - protopathic, 79

Pain—Cont'd

- due to pulmonary embolism, 91
- radicular, 91
- in rectum, 80
- due to rib cartilage slipping, 91
- due to ruptured disk, 92
- in sciatica, 110
- sensitivity to, individual, 83
- in shoulder, 92
- due to sigmoid diverticulitis, 98
- in skin, 79
- due to slipping of rib cartilage, 91
- somatic, of viscera, 93
- due to spinal cord tumor, 597
- splanchnic, of viscera, 93
- in stomach, gastric ulcer, 96
- in subcutaneous fat, 79
- substernal, 91
- due to tabes dorsalis, 100
 - gastric crisis of, 100
 - girdle pain in, 91, 100
 - lancinating in, 100
 - lightning in, 110
- in tendons, 79
- in testis, 80
- thoracic, 90
 - anginal syndrome, 90
- time of day, influence of, on, 83
- in ulcer, duodenal, 96
 - gastric, 96
 - peptic, 96
- in urethra, 81
- in uterus, 80
- in viscera, 79
 - Lennander's experiments on, 79
 - Mackenzie's theory of, 93
 - somatic, 93
 - splanchnic, 93
- Pallor, causes of, 117
 - of skin, 205
- Palpation, 160, 314-316
 - of apex beat, 316
 - of fluctuation, 160
 - of a growth or mass, 161
 - of heart, 138-139
 - of inflammation, 160
 - of P.M.T., 316
 - of thrills, 317
- Palsy, Bell's, 239
 - cerebral birth, Little's disease, 570
- Pancreas, diseases of:
 - carcinoma of ampulla of Vater, 473
 - diabetes mellitus, 237
 - hyperinsulinism, 237
 - inflammation, acute, 468
 - lithiasis (stone), 473
 - pancreatitis, 468
 - tumors of, 473
- Pancreatitis, 468
 - acute, pain due to, 99
- Panniculitis (Weber-Christian's disease), 506
- Papilledema of retina, 821
- Paralysis, agitans (Parkinson's disease), 584
 - anterior crural, 540
 - tibial, 540
 - ataxic, 540
 - crural, anterior, 540
 - deltoid, 487

Paralysis—Cont'd

- Erb's 570
- facial, 239, 538
- flaccid, 538
- infantile, 560
- of the insane, general, 595
 - paresis, 612
- Jako (Jamaica ginger paralysis), 564
- median, 540
- musculospinal, 539
- of nerves, 507-508
- oculomotor, 538
- paresis, 612
- spastic, 540, 566
- tibial, anterior, 540
- trochlear, 538
- ulnar, 539
- of vagus, 538
- Paralytic ileus, 458
- Paramyoclonus multiplex, 587
- Paramyotonia congenita, 587
- Paranasal sinuses, examination by x ray, 702
- Paraplegia, spastic paraplegic gait, 546
 - of legs, 569
 - due to multiple sclerosis, 569
- Parathyroid, adenoma of, 218
 - hyperfunction of, 218
- Paresis (general paralysis of the insane), 595, 612
- Parkinson's disease, 584, 585
 - paralysis agitans, 584
 - postencephalitic, 585
- Parkinsonian gait, 548
- Parotitis, postoperative, 253
- Paroxysmal tachycardia, 306
- Parrot fever, of lungs, 429
- Patch test, for tuberculosis, 670
- Patches, mucous, in mouth disease, 243
- Patent ductus arteriosus, 345
- Patent foramen ovale, 346
- Pectoriloquy, 400
- Peduncle syndromes, 560
- Pellagra, 199, 201
 - dermatitis in, 201
 - skin exfoliation due to, 199
- Pelvis, examination of, method of, 525
- Peptic ulcer, perforated, 756
- Percussion, 318
 - Apenbrugger's classic description of, 163
 - technique of, 161
- Periarthritis nodosa, 358-360
- Pericardial friction rub, 383
- Pericarditis, acute, 382
 - adhesive, chronic, 383
- Pick's disease of, 385-386
- polyserositis, 386
- Pericardium, diseases of, 382-384
 - effusion, 383-384
 - pain in, 90
 - Capp's experiments in, 79
- Periostitis, 501
- Peripheral diseases, 514-523
- Peritoneoscopy, 839-840
- Peritonitis, 459
- Pernicious anemia, 575
 - skin, changes in, due to, 206
- Perthe's disease, 503

- Petechiae*, 190 191
 due to endocarditis, 190
 due to Rocky Mountain fever, 191
 in skin hemorrhages, 190
- Petit mal, 593
- Phlebectasia, 291
- Phlebitis, 512 513
 migrans, 513
 thrombo-, 512 513
- Phlegmasia alba dolens, 511
- Phosphatase, 629, 635 636
 in blood, 635-636
 normal value of, 629
- Phosphorus, 629, 633
 in blood, 635
 normal value of, 629
- Phthisic chest, 277
- Physical examination, 157-158
 equipment for, 157
 inspection, 158
 order of procedure, 158
- Physiologic status, 182-183
- Pick's disease, 385-386
- Pituitary gland, diseases of:
 cachexia, Simmond's disease, 223
 Cushing's syndrome in, 223 224
 diabetes insipidus, 237
 hyperfunction, 214
 in acromegaly, 215-216
 Mark's, Leonard, description of, 216
 Simmond's disease, pituitary insufficiency, 223
- Pleura, 435-444
 Capp's experiments in pain of, 79
 effusion, 437-441
 pain due to, 90
 examination of, by x ray, 716 724
 fluids of, 722
 examination of, by x ray, 716-718
 heart displacement due to, 722
 friction rub, 402, 436
 pain in, 79
 Capp's experiments on, 79
- Pleurisy, pain due to, 90
- P.M.L. palpation, 316
- Pneumonia, 419 423
 in arthritis, 493
 broncho-, 420
 complications of, 421-423
 examination of, by x ray, 705
 lobar, 419 420
 virus, 421
- Pneumonoconiosis, 426
 examination of, by x ray, 714 715
- Pneumothorax, examination of, by x ray, 711-712
 pain due to, 91
 spontaneous, 443
 in tuberculosis, 417
- Poisoning, shoe dye, skin dis-coloration due to, 203
- Poliomyelitis, 560 561, 637
 acute, spinal fluids in, 637
 anterior, 560 561
 syndromes of, 561
- Polycythemia vera, erythemia due to, 196
- Polyneuritis, 562
 diphtheritic, 562
 infectious (Guillain-Barré syndrome), 562
- Polyferositis, pericardium*, 386
- Polyuria, 618
 causes of, 127
 due to nephritis, 127
- Popliteal artery, aneurysm of, 521
- Posterior inferior cerebellar artery, 559
 signs and symptoms of, 559
- Postmenstrual osteoporosis, 217
- Posture, 177
- Potassium, normal value of, 629
- Precipitin test, 667
 for echinococcus disease, 667
 in trichinosis, 667
- Pregnancy, 458, 502
 ectopic, 458
 osteomalacia in, 502
- Proctosigmoidoscopy, 835 836
 in carcinoma, 836
 in colitis, ulcerative, 836
 in dysentery, amebic, 836
 bacillary, 836
 examination by, method of, 835
- Progressive muscular atrophy, 180
 of Charcot-Marie type, 543
- Prolapse, 532
- Prolonged A-V conduction time, shown by electrocardiogram, 798
- Prostate, examination of, 531
- Protein, blood, 637
 normal values, 629
- Proteinuria, Renee-Jones on, 620
- Prothrombin, normal value of, 623
- Protopathic pain, 79
- Pseudohypertrophic muscular dystrophy, of Duchenne-Griesinger, 580
- Pneumosis, of the lungs, 429
- Psoas abscess, 476
- Ptoxis, 551
- Pulmonary embolus, pain due to, 91
 osteoarthritis, 497
 regurgitation, 340
 stenosis, 340, 346
 valve disease, 340
 ventilation, 634
- Pulse, diseases of, 313-314
 capillary pulse, 314
 Corrigan pulse, 313
 Duroziez's sign, 314
 water hammer pulse, 313
- Pulsus alternans, 312
- Pupil, Adie's, 574
 Argyll Robertson, 572
 Argyll Robertson reaction, 264
 regularity of, 262 263
- Purpura, 191-192
 fulminans, 521
 Henoch's, 460
 idiopathic, 192
 thrombocytopenic, 191
- Pyelography, retrograde, 778
- Pylorus, 749
 stenosis, congenital hypertrophic, of, 749
 examination of, by x-ray, 749

Q

- Queckensteit test, in cerebrospinal fluid, 655
- Quinke's disease, 200
- Quinidine, in electrocardiogram, 802, 804
- Quincy, 233

R

- Rabies, 589
- Radiculitis, 297
pain in, 91
spinal fluid in, 658
of spine, 297
- Radioperiosteal reflex, 536
- Râles, 400-401
bubbling, 401
crepitant, 400
mucous, 401
sibilant, 401
sonorous, 401
subcrepitant, 401
succussion, 401
- Raymond Cestan (or Cestan Chénais) syndrome, 560
- Raynaud's disease, 518
- Reactions, involuntary, 182
- Rectum, 532-533
diseases of:
anal fissure, 532
hemorrhoids, 532
pain in, 80
prolapse, 532
examination of, procedure, 532
- Red cells in blood, 624-625
- Reflex, 536-537
abdominal, 537
ankle clonus, 536
jerk, 536
Babinski, 537
bicep jerk, 534
cremasteric, 537
hand clonus, 536
jaw jerk, 534
knee jerk, 536
radioperiosteal, 536
supinator jerk, 534
triceps jerk, 534
- Regurgitation, 334-338, 341-343
aortic, 341-343
Flint, Austin murmur in, 343
neck pulsations due to, 267
mitral, 334-338
Graham-Steel murmur in, 338
pulmonary, 340
tricuspid, 339
- Renal function tests, normal values, 622
- Resonance, vocal, 400
- Respiration, Biot's, 175
Cheyne-Stokes, 134, 174
- Respiratory system:
bronchi, 406-410
bronchial asthma, 410-412
bronchiectasis, 406-407
bronchitis, 406-408
acute, 406
chronic, 406
fibrinous, 408
broncholithiasis, 408
foreign bodies in, 409
diaphragm, 432-435
abscess, subphrenic, 435
hernia of, 435
subphrenic abscess, 433-435
- Respiratory system—Cont'd
examination of, 396-398
interpretation of findings, 402-404
sounds:
adventitious, 400-401
breath, 399-400
voice, 400
x-ray examination of, 701-729
influenza, 405
lungs, 412-419
abscess, 423-425
atelectasis, 427
collapse, massive, 428
cysts, 424
emphysema, 426
empyema, 421-422, 442
gangrene, 423
hydrothorax, 442
massive collapse, 428
mycotic disease of, 428-429
neoplasms, 424
pneumonoconiosis, 426
pneumothorax, spontaneous, 443
syphilis of, 423
tuberculosis of, 412-417
mediastinum, 436-432
pleura, 435-444
effusion, 437-441
pleurisy, acute fibrinous, 436
pneumonia, 419-423
broncho-, 420
complications of, 421-423
lobar, 419-420
virus, 421
x-ray examination of, 701-729
- Retina, 819-821
in brain tumor, 821
in choked disk, 821
ophthalmoscopy in, 818-819
papilledema of, 821
syphilis of, 819
tuberculosis of, 820
- Retinosis, albuminuric, 820-821
diabetic, 820
- Retropharyngeal abscess, 253
- Rheumatic fever, 490
nodules of skin, 196
- Rheumatoid arthritis, 488-489
- Rhythm, nodal, shown by electrocardiogram, 801
- Riboflavin deficiency, in lip disease, 243
- Ribs, abnormalities of, 279
cartilage slipping, pain due to, 91
cervical, 275, 482-484
anesthesia due to, 112
examination by x-ray, 688-689
Tietz's disease of, 279
- Rickets, 179
bone involvement in, 502
examination of, by x-ray, 685
tetany in, 236
- Rivers and Head, pain, investigations of, 79
- Rocky Mountain spotted fever, 191
petechiae due to, 191
- Romberg's sign, 546
- Rose bengal test for liver disease, 650

S

Saber shin, 501
 Sacroiliac strain, backache due to, 108
 Saint Vitus' dance, 541
 Salivary glands, 270
 diseases of, 253-255
 in infectious diseases, 253
 Mikulicz's disease, 254
 in mumps, 253
 parotitis, 253
 epidemic, 253
 postoperative, 253
 sialolithiasis, 255
 uveoparotitis, 254
 Sarcoid, Boeck's, 193
 Sarcoma, lympho-, 271
 Scalenus anticus syndrome, 483
 Scanning speech, 548, 607
 Scapula, winged, 487
 Scarlet fever, 198, 668
 Dick test for, 668
 skin eruptions in, 198
 Schick test, 670
 Schmorl's disease, 692
 Schönlein's disease, 508
 Sciatica, 600
 pain in, 110
 Sciatic neuralgia, 600
 Scleroderma, 520
 Sclerosis:
 amyotrophic lateral, 543, 570
 spinal fluid in, 658
 arterio-, 388-389
 of aorta, 388-389
 cerebral, 612
 mental state due to, 612
 tremor due to, 585-586
 multiple, 586, 604
 paraplegia, spastic due to, 567
 spinal fluid in, 658
 Scurvy, 192, 502
 bone involvement in, 502
 examination of, by x ray, 686
 hemorrhage, subcutaneous, in, 192
 Sedimentation rate of blood, normal value, 623
 Sella turcica, examination of, by x ray, 684-685
 Septal defects, ventricular, 346
 Serum, 214, 638
 albumin, in blood, 638
 cholesterol, 214
 globulin, in blood, 638
 Sexual precocity, 225-226
 Shin, saber, 501
 Shoe dye poisoning, skin discoloration due to, 203
 Shoulder, pain in, 92
 Sialolithiasis, of salivary glands, 255
 Sick headache, 86
 Sigmoid diverticulitis, pain due to, 99
 Signs:
 Abadie's (J. M.), of exophthalmic goiter, 574
 Biernacki's (Edmund), in parietic dementia and tabes dorsalis, 574
 Brown's, in Huerger's disease, 518
 Carnett's (John Burton), abdominal tenderness, 448

Signs—Cont'd

cerebellar, 610
 Charcot's (Jean Martin), triad, in peripheral facial paralysis, 586
 Chvostek's (Franz), in tetany, 235, 542, 588
 Dairymple's (John), in exophthalmic goiter, 260
 Darrozier's (Paul Louis), in aortic insufficiency, 314
 Goldthwait's (Joel), pain in sacroiliac region, 294
 Joffroy's (Alexis), in exophthalmic goiter, 260
 Lesègue's (Ernest Charles), in sciatica, 294
 Lewin's, pain in sacroiliac region, 294
 Litten's (Moritz), in thorax, respiration, 279
 Mayo Robson (Arthur Wm.), in gallbladder disease, 448
 McBurney's (Charles), point, between umbilicus and anterior superior spine of ilium, 448
 Mobius' (Paul Julius), in eyes in goiter and migraine, 260
 Murphy's (John B.), in gallbladder disease, 448
 Romberg's (Moritz H.), in locomotor ataxia, 546
 Stellwag's (Carl), in eye in goiter, 546
 Trousseau's (Armand), in tetany, 235, 542, 589
 Von Graefe's, in exophthalmic goiter, 260
 Silver poisoning, skin discoloration due to, 204
 Simmond's disease, pituitary cachexia, 223
 Sinus, arrest, shown by electrocardiogram, 798
 arrhythmia, 309-310
 shown by electrocardiogram, 788
 bradycardia, shown by electrocardiogram, 795
 examination by x ray, 702
 paranasal, 702
 thrombotic, lateral, spinal fluid in, 658
 Sinusitis, headache due to, 88
 Skin, 199
 in Addison's disease, 232
 anemic changes in, 206
 in chlorosis, 206
 in green sickness, 206
 in pernicious anemia, 206
 in secondary anemia, 206
 carotinemia, 202
 dermatitis, in pellagra, 201
 dermatomyositis, 239, 504
 discoloration, 203-204
 due to argyria, 204
 due to bismuth, 204
 due to methemoglobinemia, 203
 due to shoe dye poisoning, 203
 due to silver poisoning, 204
 due to sulfhemoglobinemia, 203
 edema of, 206
 physiological mechanism of, 206
 in endocrine gland disease, 232
 eruptions, 197-198
 due to drugs, 196
 due to German measles, 197

Skin eruption—Cont'd

- granulomatous, 193
 - due to actinomycosis, 194
 - due to anthrax, 194
 - due to blastomycosis, 194
 - due to Boeck's sarcoid, 193
 - due to drugs, 196
 - due to glanders, 194
 - due to gumma, 193
 - due to Hodgkin's disease, 193
 - due to leprosy, 195
 - due to lupus erythematosus, disseminated, 360
 - due to sporotrichosis, 195
 - due to tuberculosis, 195
 - due to tularemia, 195
- herpetic, 200
 - due to infectious diseases, 197
 - due to measles, 197
 - due to scarlet fever, 198
 - due to syphilis, secondary, 198
 - due to typhoid fever, 198
 - due to typhus fever, 198
- urticarial wheals, 200
- vesicular, 201-202
 - due to chickenpox, 201
 - due to dermatitis venenata, 201
 - due to drugs, 201
 - due to herpes zoster, 202
 - due to smallpox, 201
- erythema nodosum, in, 196
- exfoliation, 199
 - due to drugs, 199
 - due to pellagra, 199
- Hand-Schüller-Christian's disease of, 203
- hemorrhages in, 196
 - petechiae, 190
- keratoses, 200
- pain in, 79
- pallor of, 205
- pigmentation of, due to Addison's disease, 204
 - * bronze diabetes, 204
 - due to hemochromatosis, 204
 - due to ochronosis, 205
 - quality of, 206
 - rheumatic nodules of, 196
 - syphilis, tertiary, of, 195
 - tests, 667-671
 - brucellosis, 671
 - for tuberculosis, 668-669
 - for undulant fever, 671
 - xanthomatosis of, 203
- Slit lamp, inspection by, 158-159
- Sluder's neuralgia, 89
 - sphenopalatine neuralgia (lower face), 596
- Slurring speech, 607
- Smallpox, skin eruption, vesicular, in, 201
- Sodium, normal value of, 629
- Somatic pain, visceral, 93
- Somatotypes, 183
 - clinical significance of, 186
 - ectomorphy, 184, 185
 - endomorphy, 184-185
 - mesomorphy, 184-185
- Spasm, muscular, 542
 - torsion, 591
- Spastic paralysis, 540, 566
 - of legs, 560
 - due to multiple sclerosis, 569
- paraplegic gait, 546
- Speech, 606-607
 - scanning, 548, 607
 - slurring, 607
- Sphenopalatine neuralgia (Sluder's neuralgia), 596
- Spina bifida, 296
 - examination of, by x ray, 688
- Spinal fluid, 655-658
 - in amyotrophic lateral sclerosis, 658
 - in brain abscess, 657
 - in cerebral hemorrhage, 658
 - cerebro-, 654-658
 - in cells, 655
 - changes in, due to, 656-658
 - examination of, 654-656
 - Lange test in, 655-656
 - pressure, 654-655
 - Queckenstedt test for, 655
 - in xanthochromia, 655
 - in encephalitis, epidemic, 657
 - in meningitides, acute, 656
 - in meningitis, acute, 657
 - tuberculous, 656
 - in multiple sclerosis, 657
 - in neurosyphilis, 657
 - in poliomyelitis, acute, 657
 - in radiculitis, 658
 - in sclerosis, multiple, 658
 - in sinus thrombosis, lateral, 658
 - in spinal subarachnoid block, 657
 - in syphilis of central nervous system, 657
 - neuro, late, 657
- Spine, block, subarachnoid, spinal fluid in, 657
 - disk, intervertebral syndrome, 295
- Duchenne Aran type of progressive muscular atrophy, 543
- examination of, 292-295
 - Joste's outline for, 294
- intervertebral disk syndrome, 295
- muscular atrophy, progressive, Duchenne Aran type, 543
 - osteomyelitis of, backache due to, 105
 - radiculitis of, 297
 - spina bifida, 296
 - subarachnoid block, spinal fluid in, 657
 - syphilis of, 565
 - tuberculosis of, backache due to, 104
 - tumor of, 597-599
 - neuralgia due to, 597
 - pain due to, 597
- Splanchnic pain, visceral, 93
- Spleen, 463-465
 - abscess of, 465
 - cysts of, 464
 - Gaucher's disease of, 463
 - hematoma of, 464
 - Niemann-Pick's disease of, 463
 - thrombosis of splenic vein, 464
- Splenomegaly, causes of, 463
- Spondylitis, neuralgia due to, 599
- Spondylolisthesis, 109, 693
 - backache due to, 109
 - examination of, by x-ray, 693

- Spontaneous pneumothorax, 443
in tuberculosis, 447
- Sporotrichosis, of lungs, 429
skin eruptions due to, 195
- Sputum, Charcot-Leyden crystals in, 640
Curschmann's spirals, 640
Dittrick's plugs in, 640
examination of, 640-641
tubercle bacilli in, 641
- Stature, 177, 209-211
endocrine diseases, influence of, on, 209, 211
gonads, influence of, on, 209, 211
hypothyroidism, effect of, on, 209
ossification, delayed, in, 209
pituitary gland influence on, 209, 211
thyroid gland disease influence on, 209
- Steel, Graham, murmur in mitral regurgitation, 338
- Stellwag's sign, 260
- Stenosis, aortic, 343 344
congenital hypertrophic, of pylorus, x ray examination of, 749
mitral, 334-338
pulmonary, 340, 346
tricuspid, 339
- Steppage gait, 546
- Sternum, abnormalities of, 281
- Still's disease (Feltz's syndrome), 489
- Stokes Adams syndrome, 796
- Stomach, diagnosis, differential, x-ray examination of, 758
diseases of, 746 747
achylia gastrica, 644
acidity of, normal value, 644
carcinoma of, examination of, by x ray, 757-758
Ewald-Boas test meal for gastric function, 642
examination by x ray, 745-761
methods of, 747-749
gastric contents, examination of, 642 644
fractional analysis of, 644
crisis, 574
function test meal, Ewald Boas, 542
ulcer, pain in, 96
gastroscopy in, 749
hypocholehydrin, 644
leather bottle, x ray examination of, 759
linitis plastica, x ray examination of, 759
symptoms of disease, 747
syphilis of, 461
examination of, by x-ray, 759
tumor of, benign, examination of, by x ray, 700
ulcer of, healing, examination of, by x-ray, 756
peptic, niche in, 752
types of, 751
x ray examination of, 745-746
method of, 747-749
- Stomatitis, in mouth diseases, 249
- Stool, blood in, causes of, 127
examination of, 645-646
- Streptococcal throat, 253
- Stupor, 613-615
due to arachnoid hemorrhage, 615
due to brain abscess, 614
due to encephalitis, 613
due to hematoma, subdural, 615
due to meningitis, 614
- Subarachnoid block, spinal fluid in, 657
- Subphrenic abscess, 433 434
- Substernal pain, 91
- Sugar, 620, 632
in blood, 632
in urine, 620
- Sulfhemoglobinemia, skin discoloration due to, 203
- Supinator jerk reflex, 534
- Surgery, thoracic, bronchoscopy in, 833
- Sweats, 176
- Sydenham's chorea, 541, 590
- Symptoms, interpretation of, 77
- Syncope, 153
- Syndrome, Adams Stokes, 306 307
adrenogenital, 224
anginal, thoracic, pain in, 90
anterior poliomyelitis, 561
Avelli's, 557
Babinski-Nageotte, in hemiplegia, 557
Benedict's (Moritz), in paralysis, 560
Brown Sequard, in hemiplegia, 570
Cestan Chénais (or Raymond Cestan), in hemiplegia, 560
Chiari's (Hans), in heart disease, 455
Costen's (James), in neuralgia, 736
Cushing's (Harvey), in endocrine diseases, 223 224
Feltz's (A. R.), in arthritis and splenomegaly, 463, 489
Fröhlich's (Alfred), in adiposity, 220
Guillain Barré, in neuritis, 562
Horner's (Johann-Friedrich), in paralysis of cervical sympathetic, 551-552
intervertebral disk, 295
Jackson's (James), paralysis of soft palate, larynx, and tongue, 557
Jacob's (Arthur), in eye disease, 586
Korvako's (Serge), in psychosis, 563
Ménière's (Prosper), in disease of semi-circular canals, 609
Millard Gubler-Foville, in hemiplegia, 558
Nothnagel's (Hermann), in ataxia, 560
peduncle, 560
poliomyelitis, anterior, 561
Raymond Cestan (or Cestan Chénais), in hemiplegia, 560
scalenus, anticus, 483
Stokes-Adams, in bradycardia, 306 307, 796
thoracic anginal, pain in, 90
Weber's (Hermann), in hemiplegia, 560
- Syphilis, of aorta, 549 594
dyspnea, paroxysmal, due to, 131
in arthritis, 499
of bones, 500
of central nervous system, spinal fluid in, 657
chancre in, 524, 527
Charcot's joint in, 676
Clutton's joint in, 675
congenital Hutchinson's triad, 824
dactylitis, syphilitic, 675 676

Syphilis—Cont'd

- examination by x-ray, 675-678
 - of fingers, 501
 - headache due to, 69
 - hemiplegia due to, 568
 - of larynx, 829
 - of liver, 471
 - of lungs, 423
 - examination of, by x-ray, 713-714
 - in lymph nodes, 271
 - in myocardium diseases, 379
 - neuro-, late, spinal fluid in, 637
 - in nodes, lymph, 271
 - of retina, 819
 - secondary, skin eruptions in, 193
 - of spinal cord, 565
 - of stomach, 461
 - examination of, x-ray, 759
 - syphilitic dactylitis, 675-676
 - tertiary, of skin, 195
 - tests for, 663-666
 - Wassermann, 663-664
 - of toes, 501
 - Wassermann test for, 663-664
 - x-ray examination of, 675-678
- Syphilitic aortitis, 389-394
- dactylitis, 675-676
- Syringomyelia, 497, 543, 565, 579, 603
- anesthesia due to, 112
- neuralgia due to, 599
- Systoles, extra, 309-311

T

- Tabes dorsalis, 571-572
 - anesthesia due to, 112
 - gastric crisis of, pain due to, 100
 - girdle pain in, 91-100
 - pain due to, 100
 - pain, lancinating, in, 100
 - lightning, in, 110
- Tachycardia, 305, 306
 - asthenia, neurocirculatory, 306
 - auricular flutter, 306
 - fibrillary states, 305
 - neurocirculatory asthenia, 306
 - paroxysmal, 306
 - nodal, shown by electrocardiogram, 792
 - shown by electrocardiogram, 791
 - sinus, shown by electrocardiogram, 791
 - ventricular, 306
 - paroxysmal, shown by electrocardiogram, 793
- Teeth, 245-248
 - abscess, periapical, examination of, by x-ray, 732
 - bridges, significance of, 247
 - caries, 248
 - causes of, 248
 - crown, significance of, 247
 - examination of, 245
 - by x-ray, 730-736
 - Hutchinson's, 246
 - malocclusion of, 246
 - periapical abscess, examination of, by x-ray, 732
 - x-ray examination of, 730-736
- Telangiectasis, due to cirrhosis of the liver, 193

- Temperature of body, 175
- Tendons, pain in, 79
- Tenosynovitis, 505
- Testis, pain in, 80
 - tumors of, 530-531
- Tests, for albumin, 618
 - azorubin S, for liver, 650
 - bacillary dysentery, 667
 - Bárány, 610
 - benzidine, for blood in stools, 646
 - bilirubin excretion for liver, 649
 - bromsulphalein, 650
 - for brucellosis, 667
 - carbohydrate function, for liver, 649-650
 - Dick, for scarlet fever, 668
 - for dysentery, bacillary, 667
 - Ely, 205
 - Ewald-Boas test meal for gastric function, 642
- Frei's, 528
 - lymphogranuloma inguinale, 671
 - function, carbohydrate, for liver, 649-650
 - functional, for kidney, 650-653
 - normal value, for liver, 647-648
 - glucose tolerance, 632-633
 - in blood, 632
 - in urine, 633
 - gold, colloidal, for cerebrospinal fluid, 655-656
 - hearing, 266
 - hippuric acid synthesis, for liver, 650
 - icterus index, for liver, 649
 - immunologic, 662-671
 - kidney function, 622, 650-653
 - Lange's (Carl), for cerebrospinal fluid, 655-656
- Mantoux (Charles), for tuberculosis, 669
- Ober's, 295
- patch, for tuberculosis, 670
- phenolsulfonephthalein, for kidney, 652
 - for echinococcus disease, 667
 - for trichinosis, 667
- Queckenstedt's (Hans), in cerebrospinal fluid, 655
- renal function, 622
- rose bengal, for liver, 650
- Schick (Béla), for diphtheria, 670
- Skin, 667-671
 - for syphilis, 663-666
 - for tuberculosis, 668-669
 - for tularemia, 667
 - for undulant fever, 667, 671
 - urea clearance test for kidney disease, 652
 - Wassermann, for syphilis, 663-664
 - Widal, for typhoid fever, 666
 - Von Pirquet's, for typhoid fever, 666
- Tetanus, 589
- Tetany, 542, 588
 - Chvostek's sign in, 235
 - in endocrine disease in muscular system, 235
 - due to rickets, 236
 - Trousseau's sign in, 235
 - due to vitamin deficiency, 236
- Tetralogy of Fallot, 346
- Thomsen's disease, myotonia congenita, 542, 586-587
- Thoracic anginal syndrome, pain in, 90

- Thorax, lateral, examination of, by x ray, 720-727
 oblique, examination of, by x ray, 726-727
 as resonator in occultation, 168-169
 surgery of, bronchoscopy in, 833
 Thrills, palpation of, 317
- Throat, 253
 hoarseness in, 144
 septic sore, 253
 streptococcic, 253
- Thromboangiitis obliterans, 517-518
 Thrombocytopenia, in purpura, 191
 Thrombosis, 454
 coronary, J. R. Herriek on, 802
 mesenteric, 458
 of splenic vein, 464
- Thymus, examination of, by x-ray, 726
 Thyroglossal cyst, 275
 Thyroid gland, diseases of:
 basal metabolism in, 816-817
 cholesterol in, 637
 edema due to hypothyroidism, 138
 exophthalmic goiter, 239
 goiter, diffuse, nontoxic, 274
 toxic, 274
 exophthalmic, 274
 tremor due to, 586
 nodular, nontoxic, 274
 toxic, 274
 hypothyroidism, 212-214
 in children, 212-213
 dwarfism due to, 213
 edema due to, 138
 epiphyseal dysgenesis in, 214
 metabolism, basal, in, 816-817
 myxedema, 220-222
 stature, effect of, on, 209
 swellings of, 273, 274
 Thyroid intoxication in tachycardia, 305
 Thyrotoxicosis, in myocardium, diseases of, 381
- Tibial paralysis, anterior, 540
 Tic, 541, 589
 douloureux (trifacial neuralgia), 595-596
 headache due to, 89
- Tietz's disease, of ribs, 279
 Tongue, diseases of, 250-251
 Tonsils, diseases of, 251-253
 abscess, retropharyngeal, 253
 examination of, 251
 infections of, 252
 quinsy, 253
 retropharyngeal abscess, 253
 septic sore throat, 253
 sore throat, 253
- Tophi, in gout, 493, 496
 Torsion spasm, 591
 Torticollis, 542, 589
 Trachea, examination of, by x-ray, 702
 Transillumination, inspection by, 158
 Transudates, examination of, 659-661
 Trauma, headache due to, 107
 Tremor, 541
 causes of, 155
 arteriosclerosis, 585-586
 exophthalmic goiter, 586
 hypoglycemia in endocrine disease of
 muscular system, 276
 intention, 541
- Triceps jerk reflex, 534
 Trichinosis, precipitin test for, 667
 Tricuspids, regurgitation, 339
 stenosis, 339
 Trigeminal neuralgia, headache due to, 89
 Trochlear paralysis, 538
 Trophic ulcers, 507
 Trousseau's sign, 542, 589
 Trunk, anesthesia, 574
 Tuberculin, 669
 Tuberculosis, 412-417
 of abdomen, 476
 in arthritis, 490
 of bone, 500
 in childhood, 414
 consumption, galloping, 415
 diagnosis, differential, 417
 examination by x-ray, 673-675
 of ileocecal, 476
 intestinal, 417
 examination of, by x ray, 769
 of larynx, 825-828
 of lymph nodes, 271
 Mantoux test for, 669
 milhary, 414
 examination of, by x-ray, 712
 patch test for, 670
 pneumothorax, spontaneous in, 417
 pulmonary, examination of, by x ray, 705
 712
 of retina, 820
 skin eruptions, granulomatous, due to, 195
 test for, 668-669
 spinal, headache due to, 104
 spontaneous pneumothorax, 417
 sputum, 640-641
 bacilli, tubercle in, 641
 Charcot-Leyden crystals in, 640
 Curschmann's spirals in, 640
 Dittrich's plugs in, 640
 examination of, 640-641
 tests for, Mantoux, 669
 patch, 670
 skin, 668-669
 Von Pirquet's, 669
 tuberculin test for, 669
 Von Pirquet's test for, 669
 x-ray examination of, 673-675
- Tularemia, 195, 429, 667
 of lungs, 429
 skin eruption, granulomatous, due to, 195
 test for, 667
- Tumors, abdominal, 462
 of right lower quadrant, 477
 adenoma, due to hyperinsulinism, 237
 arrhenoblastomata of ovary, 224
 of bones, 501
 examination of, by x ray, 680-683
 of brain, 89, 568, 610-611
 headache due to, 89
 due to hemiplegia, 563
 mental state disturbance due to, 610-611
 carotid, 275
 cerebellopontine angle, 576, 609
 of kidney, examination of, by x ray, 780
 781
 Krukenberg, 462
 of larynx, 829

Tumors—Cont'd

- of liver, 472
- ovarian, 224, 458
 - arrhenoblastomata of, 224
 - with twisted pedicle, 458
- of pancreas, 473
- retroperineal, 465
- of spinal cord, 598
 - neuralgia due to, 597
 - pain due to, 597
- of stomach, benign, 760
- testis, 530-531
- Typhoid fever, 198, 666
 - skin eruptions due to, 198
 - Widal test for, 666

U

Ulcers:

- duodenal:
 - examination of, by x-ray, 761-763
 - pain due to, 96
- esophageal, examination of, by x-ray, 744
- gastric:
 - examination of, by x-ray, 751-757
 - malignant, examination of, by x-ray, 754
 - pain due to, 96
- peptic, 753, 756
 - niche in, 752
 - perforated, 756
- stomach, 751, 756
 - healing, examination of, by x-ray, 756
 - types of, 751
- trophic, 507
- Ulnar paralysis, 539
- Umbilicus, diseases of, 286-287
- Undulant fever, 105, 667, 671
 - backache due to, 105
 - brucellosis test, 667
 - skin test for, 671
- Urea, in blood, 631
- Urethra, pain in, 81
- Uric acid, 493, 631
 - in blood, 631
 - in gout, 493
- Urinary bladder, pain in, 80
- Urination, frequency of, 127-128
- Urine, 618-619
 - albumin in, 618-619
 - tests for, 618
- albuminuria, 619
 - causes of, 619
 - orthostatic, 619
- examination of, microscopic, 620-621
- glucose tolerance test, 632-633
- glycosuria, causes of, 620
- hemoglobinuria, paroxysmal, 617
- nocturia, 618
- normal values, 621
- polyuria, 618
- proteinuria, Bence Jones on, 620
- sugar in, 620
- test, glucose tolerance, 632-633
- Urogenital tract, examination of, by x-ray, 778-782
- Urticarial wheals, 200
- Uterus, pain in, 80
- Uveoparotitis, 254

V

- Vagus paralysis, 538
- Valve, pulmonary, 340
- Van den Bergh reaction, 649
- Varices, of esophagus, examination of, by x-ray, 742-743
- Varicose veins, 514
- Vater, carcinoma of ampulla, 473
- Veins, diseases of, 291, 512-514
 - phlebectasis of, 291
 - phlebitis migrans, 513
 - Buerger's disease in, 513
 - splenic thrombosis of, 464
 - thrombophlebitis, 512-513
 - thrombosis, axillary, 514
 - splenic, 464
 - subclavian, 514
 - varicose, 514
- Ventral hernia, 289
- Ventricular extrasystoles, shown by electrocardiogram, 789
- preponderance, shown by electrocardiogram, 788
- septal defects, 346
- strain, left, shown by electrocardiogram, 811
- right, shown by electrocardiogram, 812
- tachycardia, 306
- Ventriculography, examination of, by x-ray, 783
- Vertigo, 608
 - causes of, 155
 - due to Ménière's disease, 155
- Vesicular breathing, 399
- Vincent's infection of gums, 244
- Virchow's node, 462
- Virus pneumonia, 421
- Viscera, 93-94
 - abdominal pain in, John Morley mono-graph on, 94
 - hyperalgesic areas in, 94
 - Lennander's experiments on pain in, 79
 - pain in, 79, 93
 - Lennander's experiments on, 93
 - Mackenzie's theory of, 93
 - somatic, 93
 - splanchnic, 93
- Vital capacity, diminished, 132
- Vitamin deficiency, 236, 243, 257, 502, 563
 - in eyes, 257
 - in lip diseases, 243
 - in multiple neuritis, 563
 - in osteomalacia, 502
 - in tetany, 236
- Vocal fremitus, 397
- resonance, 460
- Volkman's contracture, 505
- Vomiting, causes of, 115-116
- Von Gierke's disease, 456
- Von Graefe's sign, 260
- Von Pirquet's test, for tuberculosis, 669
- Von Recklinghausen's disease, osteitis fibrosa cystica, 218

W

- Wassermann test, 663-664
 Water hammer pulse, 313
 Weber-Christian disease, panniculitis, 506
 Weber's syndrome, 560
 Weight, loss of, causes of, 117
 Weights, standards, 176
 Weil's disease, jaundice due to, 123
 Werdnig-Hoffman atrophy, 580
 type of muscular atrophy, spinal, progressive, 543
 Wheals, urticarial, 200
 White cells, in blood, 625
 Widal test, 666
 Wilson's disease, hepatolenticular degeneration, 570-571
 Winged scapula, 487
 Wolf-Behndler gastroscope, 838
 Wrist drop, 507, 551
 Writer's cramp, 589

X

- Xanthochromia, 203, 636, 655, 686
 cerebrospinal fluid in, 655
 cholesterol in, 636
 examination of, by x-ray, 686
 of skin, 203
 X-ray examination, 672-783
 in acromegaly, 684
 in actinomycosis, 680
 in aneurysm, 700
 of aorta, 697-699
 of appendix, 765
 in arthritis, 689-693
 in blastomycosis, 680
 in bone tumors, 680-683
 of bronchi, 702-704
 of bronchiectasis, 703
 of coarctation of aorta, 699-700
 in colitis, ulcerative, 768-769
 of colon, 765-768
 carcinoma of, 771-772
 tumors of, 771
 congenital anomalies, 698-699
 in constipation, 772-773
 of diaphragm, 727-730
 in diverticulitis, 770
 in empyema, 723-724
 in epiphysis, 685, 698
 of esophagus, 736-745
 cardio-pneum of, 741-742
 diverticulum of, 737
 foreign bodies in, 737
 stricture of, 740
 tumors of, 738-739
 ulcer of, 744
 varices of, 742-743
 of gallbladder, 774-778
 visualization by dye, 774-776
 gastric ulcer, malignant, 754
 in gout, 686
 of heart, 695-701
 measurements of, 700-701
 shadows of, 696
 in Hirschsprung's disease, 766-769
 X-ray examination—Cont'd
 of ileitis, regional, 764-765
 of intestines, 761-774
 of kidney, 778-781
 in hydronephrosis, 779
 stone of, 778
 tumors of, 780-781
 of lungs, 713-715
 abscess of, 714
 cyst of, 715
 syphilis of, 713-714
 of mediastinum, 725-727
 in myeloma, multiple, 683
 in myositis ossificans, 695
 of nervous system, central, 783
 in encephalography of, 783
 myelography of, 783
 ventriculography of, 783
 in nucleus pulposus, 692
 in osteitis fibrosa cystica, 686-687
 in osteomyelitis, 678-680
 in Paget's disease, 686
 of paranasal sinuses, 702
 of pleura, 716-724
 fluids, 716-718
 in pneumonia, 705
 of pneumoconiosis, 714-715
 of pneumothorax, 711-712
 in polyposis, 771
 of respiratory system, 701-729
 of ribs, 689-689
 in rickets, 685
 in scurvy, 686
 of sella turcica, 684-685
 of sinuses, 702
 of spina bifida, 688
 in spondylolisthesis, 693
 of stomach, 745-761
 carcinoma of, 757-758
 congenital hypertrophic stenosis of pylorus, 749
 in diagnosis, differential, 758
 for foreign bodies in, 759
 leather bottle stomach, 759
 of linitis plastica, 759
 methods of examining, 747-749
 syphilis of, 759
 tumors of, 760
 ulcers of, 756
 of syphilis, 675-678
 of lung, 713-714
 of teeth, 730-736
 in periapical abscess of, 732
 of thorax, 726-727
 lateral, 726-727
 oblique, 726-727
 of thymus, 726
 of trachea, 702
 in tuberculosis, 673-675
 milliary, 712
 pulmonary, 705-712
 in treatment of, 769
 in tumors of bone, 680-683
 in ulcer, duodenal, 761-763
 gastric, 751-757
 malignant, 754
 of urogenital tract, 778-782
 in xanthomatosis, 686

